Parasites and Diseases of Some Marine Finfish Off Nova Scotia

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January 1986

Canadian Technical Report of Fisheries and Aquatic Sciences 1424

86-01883/

Canadian Technical Report of Fisheries and Aquatic Sciences

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Fisheries and Aquatic Sciences 1424

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by

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Cat. No. Fs 97-6/1424E ISSN 0706-6457

Correct citation for this publication:

Morrison, C.M., G. McClelland, J. Cornick and D. Marcogliese. 1986. Parasites and diseases of some Marine Finfish off Nova Scotia. Can. Tech. Rep. Fish. Aquat. Sci. 1424: v + 36 p.

CONTENTS

Abstract/Résumé v

Introduction 1

Materials and methods 1

Histopathology 1

Parasitology 1

Microbiology 2

Observations 2

1. Gills 2

2. Spleen 3

3. Kidney 3

4. Digestive tract 4

5. Liver 4

6. Gallbladder 4

7. Swimbladder 5

8. Heart 5

9. Gonads 5

10. Muscle and skin 5

11. Pseudobranch 5

12. Blood smears 5

Discussion 5

New records 6

Acknowledgements 8

References 8

Captions 10

CONTENTS

Figures. 14

Table 1- Histopathology - 1980 Survey - Scotian Banks 26

Table 2- Histopathology - 1981 Survey - Approaches to Halifax harbour, off Chebucto Head. 28

Table 3- Histopathology - 1981 Survey - Emerald Bank. 31

Table 4- Histopathology - 1979 Herring Survey - Grand Manan, Bay of Fundy. 20 fish sampled 33

Table 5- Histopathology - 1981 Herring Survey - Gulf of St. Lawrence. 20 fish sampled (10 from Escuminac, 10 from Shediac). 33

Table 6- Histopathology - 1982 Herring Survey, from Chebucto Head area in approaches to Halifax harbour. 28 fish sampled. 33

Table 7- Histopathology - 1984 Pollock Survey, Dark Harbour, Grand Manan, near cages containing salmon (10 juveniles 28-33 cm long).. 33

Table 8- Prevalence of some parasite species found during 1980 Marine fish survey of Scotian Bank. 34

Table 9- Parasitology - species of parasites found and sites in samples 34

Table 10- Microbiological Surveys of Marine fish species by Fish Health Service Unit 1980-82. 35

Table 11- Diagnoses - Individual Marine species cases submitted to the Fish Health Service Unit 1981-1984. 36

ABSTRACT

Morrison, C.M., G. McClelland, J. Cornick and D. Marcogliese. 1986. Parasites and diseases of some marine finfish off Nova Scotia. Can. Tech. Rep. Fish. Aquat. Sci. 1424: v + 36 p.

The microbes and parasites, and the pathological changes produced by these and unknown agents are described in marine finfish off Nova Scotia. The histopathology of gills, liver, intestine, spleen, pyloric caeca, and in some cases kidney, head kidney, gonad, heart, swim-bladder, brain, thyroid, stomach, muscle, and any gross abnormalities were studied from alewife, Alosa pseudoharengus; herring, Clupea harengus harengus; cod, Gadus morhua; haddock, Melanogrammus aeglefinus; silver hake, Merluccius bilinearis; pollock, Pollachius virens; mackerel, Scomber scombrus; Atlantic wolffish, Anarhichas lupus; snake blenny, Lumpenus lumpretaeformis; redfish, Sebastes sp.; sea raven, Hemitripterus americanus; witch flounder, Glyptocephalus cynoglossus; halibut, Hippoglossus hippoglossus; American plaice, Hippoglossoides platessoides; yellowtail flounder, Limanda ferruginea and winter flounder Pseudopleuronectes americanus. Blood smears, preserved viscera and frozen bodies from some of these fish were examined for parasites. Samples of kidneys and sometimes other organs showing abnormalites were taken for bacteriological and viral examination. Several parasites and microbes were found in new hosts. These include prokaryote organisms in the gills of redfish, herring, halibut, snake blenny, sea raven and American plaice; Aeromonas salmonicida and Infectious Pancreatic Necrosis virus in cod; Ichthyobodo sp. in haddock; trichodinids on the gills of cod, mackerel and yellowtail flounder; coccidia in the livers of silver hake, mackerel and gaspereau and the kidneys of haddock and cod; haemogregarines in silver hake, mackerel, flatfish and redfish; myxosporidia in the gall bladder of pollock and the kidneys of cod and haddock; Hysterothylacium sp(p) in pollock and plerocercoids in redfish, pollock, sea raven and silver hake. Aporocotyle simplex was found to be more widespread than previously reported, and didymozoid trematodes were found in a mackerel from the Western Atlantic for the first time. Abnormalities were found in 89% of the gills sampled, and also the majority (55%) of the kidneys.

Key Words: pathology, microbiology, parasites, prokaryotes, bacteria, viruses, protozoa, finfish.

RÉSUMÉ

Morrison, C.M., G. McLelland, J. Cornick et D. Marcogliese. 1986. Parasites and diseases of some marine finfish off Nova Scotia. Can. Tech. Rep. Fish. Aquat. Sci. 1424: v + 36 p.

On décrit les microbes et les parasites ainsi que leurs effets pathologiques et ceux d'agents inconnus sur le poisson de mer, à la hauteur de la Nouvelle-Écosse. L'étude histopathologique a porté sur les branchies, le foie, les intestins, la rate, le caecum pylorique et, dans certains cas, sur les reins, le pronéphros, les gonades, le coeur, la vessie natatoire, le cerveau, la thyroïde, l'estomac, et les muscles de différents poissons. On a aussi étudié toute anomalie évidente. Les travaux ont porté sur les espèces suivantes gaspareau (Alosa pseudoharengus), hareng (Clupea harengus harengus), morue (Gadus morhua), aiglefin (Melanogrammus aeglefinus), merlu argenté (Merluccius bilinearis), goberge (Pollachius virens), maquereau bleu (Scomber scombrus), loup atlantique (Anarhichas lupus), lompénie-serpent (Lumpenus lumpretaeformis), sébaste (Sebastes sp.), hémitriptère atlantique (Hemitripterus americanus), plie grise (Glyptocephalus cynoglossus), flétan de l'Atlantique (Hippoglossus hippoglossus), plie canadienne (Hippoglossoides platessoides), limande à queue jaune (Limanda ferruginea) et plie rouge (Pseudopleuronectes americanus). On a recherché la présence de parasites dans les frottis sanguins, les viscères preservées et les carcasses congelées de certains de ces poissons. Des échantillons de reins et quelques échantillons d'autres organes présentant des anomalies ont été prélevés pour être soumis à un examen bactériologique et viral. Plusieurs parasites et microbes ont été trouvés chez de nouveaux hôtes. Il s'agissait, entre autres, d'organismes procaryotes présents dans les branchies de sébaste, de hareng, de flétan de l'Atlantique, de lompénie-serpent, d'hémitriptère atlantique et de plie canadienne; d'Aeromonas salmonicida et du virus de la Nécrose Pancréatique Infectieuse chez la morue; d'Ichthyobodo sp. chez l'aiglefin; des trichodinidés sur les branchies de morue, de maquereau bleu et de limande à queue jaune; de coccidies dans le foie de merlu argenté, de maquereau bleu et de gaspereau et dans les reins d'aiglefin et de morue; d'haemogrégarinidies chez le merlu argenté, le maquereau bleu, les poissons plats et le sébaste; de myxosporidies dans la vessie natatoire de goberge et dans les reins de morue et d'aiglefin; d'Hysterothylacium sp (p) chez la goberge et de plérocercoïdes chez le sébaste, la goberge, l'hémitriptère atlantique et le merlu argenté. Aporocotyle simplex était plus répandu qu'on ne l'avait signalé et, pour la première fois, des trématodes didymozoïdes ont été trouvés chez un maquereau bleu de l'Atlantique-Ouest. On a constaté la présence d'anomalies dans 89% des branchies échantillonnées et dans la majorité des reins (55%).

INTRODUCTION

There is a large but incomplete body of literature which describes the gross appearance of abnormalities in marine fish, often those associated with pollution (e.g. Ribelin and Migaki 1975, Sindermann 1970, Sindermann et al. 1978, Sindermann 1979, and Möller 1981). For several years finfish with gross abnormalities such as tumours, parasites and unusual pigmentation have been submitted to the Halifax Laboratory by fishermen, scientists on cruises, and port observers. Specimens have also been submitted after unusual fish kills in wild populations, and from hatcheries where mortalities have been unusually high, or where abnormalities such as ulcers, fin rot or unusual swellings have been noted. In addition, we have carried out several small surveys of finfish around Nova Scotia. These surveys have been restricted because the only expertise normally available was pathology, protozoan parasitology and microbiology, although some more complete parasitological work was done on samples from a cruise on the Scotian Shelf in 1980. It is impossible to do a complete study of all tissues of all marine finfish, nevertheless we were in the unusual position of being able to accumulate material showing variations of normal structure as well as abnormalities in a variety of marine finfish, mostly commercially important species. Although this information is incomplete, we feel that it should be made available to other scientists. It is therefore tabulated, described and in some cases illustrated in this report. References to relevant publications on these abnormalities are given.

MATERIALS AND METHODS

HISTOPATHOLOGY

Samples submitted to the Fish Health Service Unit by outside agents were caught in a variety of ways. They were usually fixed in 10% buffered formalin. Herring from a 1979 survey in the Bay of Fundy and a 1981 survey in the Gulf of St. Lawrence were seined and sampled at dockside, then the samples were placed in 10% formalin. In 1982 herring from the approaches to Halifax harbour were caught in a trawl and samples of liver and gonad were taken on board. In a survey carried out in July, 1980, fish were caught at several sites along the Scotian Banks in five-minute trawls. Herring, Clupea harengus harengus; cod, Gadus morhua; haddock, Melanogrammus aeglefinus; silver hake, Merluccius bilinearis; pollock, Pollachius virens; mackerel, Scomber scombrus; redfish, Sebastes sp.; witch flounder, Glyptocephalus cynoglossus; halibut, Hippoglossus hyppoglossus; American plaice, Hippoglossoides platessoides, yellowtail flounder, Limanda ferruginea and winter flounder Pseudopleuronectes americanus were sampled on board the vessel. Guts were excised whole and fixed in Dietrich's solution, and after fixation samples of gill, kidney, liver, intestine, spleen and pyloric caeca were processed for light microscopy. Some specimens of abnormal gonads and swim-bladders were also collected. It was found that the internal epithelial surfaces of the alimentary canal had often deteriorated, so in April 1981 another survey was undertaken and the gills were also fixed for electron microscopy. Sampling was limited to two sites, one in the approaches to Halifax harbour near Chebucto Head, and the other on the Emerald Bank on the Scotian Shelf. Specimens of gills, kidney, liver, intestine, spleen, pyloric caeca, head kidney, gonad, heart and any special abnormalities noted were taken from alewife (gaspereau), Alosa pseudoharengus; herring; cod; haddock; silver hake; Atlantic wolffish, Anarhichas lupus; snake blenny, Lumpenus lumpretaeformis; sea raven, Hemitripterus americanus; witch flounder; halibut; American plaice, and yellowtail flounder. All specimens, except the gills, were fixed in 4% formaldehyde (made fresh from paraformaldehyde) in 0.1 M phosphate buffer at 4°C. Gills were placed in the same fixative with 1% glutaraldehyde added. Electron microscopy was carried out on any gill samples which were found to have interesting lesions using light microscopy. More detailed studies were carried out on some protozoan parasites, and for these special cruises were sent out to collect samples in formaldehyde-glutaraldehyde phosphate-buffered fixative for electron microscopy.

In 1984 samples of gills, liver, gall bladder, stomach, pyloric caeca, intestine, spleen, kidney, gonad and heart were obtained from 10 juvenile pollock from Dark Harbour, Grand Manan.

Routine embedding and staining techniques, as described in Morrison and Sprague 1981a, were used for light and electron microscopy. The Feulgen- picro-methyl blue stain (Farley, 1969) was used on some paraffin sections of gills to demonstrate rickettsias. The Brown and Brenn stain (Humason, 1979) was sometimes used to demonstrate the polar capsules of myxosporidia.

Parasites in tissue sections were identified with the aid of Cosgrove (1975) and Margolis & Arthur (1979). Hoffman (1975) was helpful in classifying helminths in tissue sections.

PARASITOLOGY

During the July, 1980 survey, after the viscera and gill arches had been removed and fixed in Dietrich's fixative as described above some of the bodies of herring, cod, haddock, silver hake, pollock, mackerel, redfish and flatfish were frozen. After removal of samples for histological examination the preserved viscera and gills, and the frozen bodies, were inspected macroscopically for parasites and tissue abnormalities. Some metazoan parasites were cleared, stained (cestodes and trematodes) and identified following microscopic examination. Lesions, cysts and other abnormalities found in preserved viscera and gills were excised and saved for histopathological studies. Blood smears were also taken on the 1980 survey, stained with Giemsa stain and scanned for parasites and inclusions in the blood cells.

MICROBIOLOGY

Examination of fish for bacterial and viral fish pathogens was carried out by the Fish Health Service Unit (FHSU) at the Halifax laboratory. Samples of herring, cod, haddock, silver hake, pollock, mackerel, redfish, halibut, American plaice and yellowtail, witch and winter flounder

were collected by the unit on the July 1980, and April 1981 surveys, and also in the summer of 1981. In the spring and summer of 1981 and 1982, herring were sampled at two sites (Escuminac, and Shediac, N.B.) in the southern Gulf of St. Lawrence, Chebucto Head, and the Bay de Chaleur. Numerous individual samples or specimens submitted to the FHSU during the period from 1980-1984 were also examined.

Fish collected at sea were either returned to the laboratory whole on ice then samples were removed for culture of bacteria, or tissues were aseptically removed on board, frozen and subsequently cultured ashore. The fish were opened, any abnormalities recorded and samples taken from the kidneys and from any other tissues if they showed abnormalities. The samples were cultured on Tryptic Soy Agar with and without supplement to 2% NaCl as well as Cytophaga Agar and Blood Agar. Cultures were incubated at 22°C and bacterial isolates were identified according to the methodology outlined in Lee, Gibson and Shewan (1977).

For viral fish pathogens tissue samples from several fish were pooled. Kidneys, spleens and pyloric caeca were examined. The procedures outlined in the Fish Health Protection Regulations Manual of Compliance were followed. In addition to the two cell lines routinely used (RTG-2 and FHM), a sensitive chinook salmon embryo cell line (CHSE) was used. In some cases, a set of inoculated monolayers was incubated at a reduced temperature to detect Herpes virus.

OBSERVATIONS

Abnormalities found using techniques for histopathology, parasitology and microbiology are described in detail below according to the organ in which they occurred. The results of surveys are tabulated in Tables 1-11. Tables 1-7 summarize results using histopathology, Tables 8 and 9 parasitology and Tables 10 and 11 microbiology.

In sectioned material the greatest prevalence of tissue abnormalities (Tables 1-7) were found in gills (89%). Abnormalities were also found in most kidneys (55%), and in many samples of pyloric caeca (50% - mainly larval helminths), head kidneys (33%), livers (29%), intestines (26%), hearts (17%), gonads (17%), and gall-bladders (16%). Few abnormalities were found in spleens (2%).

Coarse eosinophilic granular leucocytes were often observed in sectioned material of the gills and digestive tract. In the gills they were usually in the filament, and were especially numerous in silver hake and witch flounder. They also occurred in the gills of redfish, some haddock and herring. In the digestive tract, they were plentiful in gaspereau, herring, wolffish and mackerel, and some were found in the snake blenny. They were more numerous in the intestine than in the pyloric caeca, and were usually found in the loose connective tissue of the submucosa. Rodlet cells were also common, usually in the epithelia of the digestive tract and kidneys. Their distribution and morphology have been described in several marine fish (Morrison and Odense 1978). They are only recorded as abnormalities if they were found in unusually large numbers.

1) GILLS

Aneurisms:- frequent (Tables 1-3,5, Fig. 1). More common in 1980 than in later surveys.

Hyperplasia, clubbing and fusion:- these abnormalities were grouped together because they were often seen in the same sample. Fusion of lamellae often resulted from hyperplasia of two adjacent lamellae. Clubbing seemed to be caused by hyperplasia at the apex of a lamella. Sometimes hyperplasia was accompanied by presence of many mucous cells. These changes were seen in some samples of most species (Tables 1-7, Fig. 2).

Procaryote organisms:- intracellular inclusions consisting of granular, rod-like or filamentous basophilic organisms were seen in paraffin sections of redfish (Fig. 3), herring (Fig. 4), halibut, snake blenny, sea raven (Fig. 5 and 6) and American plaice, (Tables 1-7). An inclusion in a paraffin section of sea-raven gill (Fig. 5) re-embedded for electron microscopy (Fig. 6) showed numerous organisms surrounded by a double membrane. Since they were all similar in size and sometimes were a little denser in the centre, they were probably epitheliocystis. Samples of the procaryote in American plaice were collected for resin embedding for light and electron microscopy (Fig. 7 and 8), and were demonstrated to be epitheliocystis organisms (Morrison and Shum 1983)

Microspora - xenomas of Loma morhua:- in cod and haddock (Tables 1 and 3, Fig. 9 and 10). Detailed studies have been carried out on this microsporidium (Morrison and Sprague 1981a and b).

Ciliophora - Trichodinids:- on the gills of two mackerel (Table 1, Fig. 11), one yellowtail flounder (Table 3, Fig. 12), and on cod in our aquaria (Fig. 13 and 14). In the mackerel and cod the trichodinids were easily seen, but in the yellowtail flounder they were so closely apposed to the gill that they were not originally noticed and might easily have been missed in other samples.

Sarcomastigophora - Ichthyobodo sp. (syn. Costia sp.):- on one haddock (Table 3, Fig. 15). Mean length: 8.6 µm (S.D.±1.1), mean width: 4.9 µm (S.D.±1.6) N = 10. Described in Morrison and Cone, in press.

Platyhelminthes - Aporocotyle simplex:- (see Thulin, 1980) eggs and early developmental stages in the gills of 19 out of 22 American plaice surveyed (Tables 1-3, Fig. 7, 16 and 17).

- metacercaria:- occasionally in the gill filaments of cod, haddock, pollock and mackerel (Tables 1, 2, 7, Fig. 18).

Monogenea - Anthocotyle merluccii:- on silver hake from approaches to Halifax harbour, sampled for gill lesions in 1979. The suckers of the opisthaptor were attached to the gill lamellae with the aid of internal sclerites (Fig. 22).

Nodules of unknown etiology:- in 9/25 cod 9/20 haddock, 5/14 silver hake and 1/4 mackerel (Tables 1-3, Fig. 19). They were rounded, and appeared to be in various stages of degeneration as host macrophages and/or fibroblasts accumulated around them. The prevalence of this organism in cod, haddock, red hake, silver hake and white hake is reported by Murchelano et al., 1985. A similar nodule has also been reported in blue whiting (MacKenzie, 1979). The prevalence of the organism in mackerel, and its appearance using light and electron microscopy in mackerel, cod, haddock and silver hake has been described (MacLean, Morrison and Murchelano, submitted).

Unidentified multicellular organisms attached to external surface of gills:- two cod, one from the 1980 marine fish survey (Table 1, Fig. 20), one from the Halifax Laboratory aquarium (Fig. 21), had small organisms attached to the gills.

Arthropoda-Copepoda. (Table 8) - Clavella adunca:- in cod, haddock and pollock.
- Lernaeocera branchialis:- in one cod.
- Hatschekia hippoglossi:- in some flatfish.

2) SPLEEN

The spleens had the normal microscopic organization already described in teleosts (Groman 1982). The arterioles in the centres of the ellipsoids were usually distinct, but it was often difficult to distinguish the red and white pulp. It was found that the organization, size and pigmentation of the melano-macrophage centres were typical for each species, although the number of centres varied individually. Discrete centres were not seen in herring, sea-raven or gaspereau spleens, although there were scattered macrophages containing melanin. Mackerel had centres which contained mainly black but some yellow pigment, and halibut had small centres containing mainly black pigment. Cod and haddock had relatively few, small centres with mainly darkly-pigmented melanin in formalin-fixed material, although spleens fixed with Dietrich's solution also had much yellow pigment (Fig. 23). The centres in silver hake were larger and very heavily pigmented with black and yellow (Fig. 24). Most flatfish, redfish and wolffish had numerous centres with much pigment, mainly of a yellow color (Fig. 25).

Microspora:- nodules of Loma morhua in the spleen of one cod in the 1981 survey (Table 3); in several cod samples from Terence Bay near Halifax (Morrison 1983)

Nematoda:- unidentified larva in a silver hake spleen (Table 1, Fig. 25).

3) KIDNEY

These had the typical structure already described in other fish except for the adrenal tissue of the American plaice and witch flounder, which in paraffin sections appeared as large, rounded, fairly well-defined areas (Fig. 27). Melano-macrophage centres were found in many trunk- and head-kidneys (Fig. 28), and looked similar to the centres in the spleens of the same species.

Bacteria and viruses:- the only viral fish pathogen isolated was Infectious Pancreatic Necrosis Virus (IPNV) from cod collected in the Bay of Fundy in July - 1980. This virus is commonly associated with salmonids where it causes mortality at the fry stage.

Although kidney tissue was routinely cultured, no bacteria normally considered infectious were detected in any of the surveys (Table 10).

Vibrio anguillarum and Pseudomonas sp. were cultured from kidneys of cod and haddock which died in the Halifax Lab. aquarium, (Table 11) and Aeromonas salmonicida was cultured from cod kidneys and was subsequently shown to cause lethal infection of salmon and cod when injected experimentally (Cornick, Morrison, Zwicker and Shum 1984). A. salmonicida was not detected in the kidneys of 30 wild cod.

Apicomplexa - Coccidia:- zygotes, sporoblasts and spores of an unidentified coccidian in the ducts of 3/16 cod and 10/20 haddock kidneys, and 2/16 cod and 6/20 haddock head kidneys from the 1981 survey (Tables 2 and 3) (Fig. 30, 31 and 32). Occasional zygotes were seen in the wall of the tubule (Fig. 30). Often coccidia were seen in the centres of granulomas in kidney tissue (Fig. 33). The mean length of the spore from 10 measurements was 9.7 µm, (±0.7), the mean width was 4.5 µm, (±0.4).

Myxozoa:- the mesonephric duct and often smaller ducts in the kidneys of 11/16 cod, 9/20 haddock and possibly 1/5 yellowtail flounders, and head-kidneys of 10/16 cod and 8/20 haddock from the 1981 survey (Tables 2 and 3) contained myxosporidians (Fig. 34). A polar capsule could be seen at each end of the spore (Fig. 35). In a squash preparation the coils of the polar filament were visible (Fig. 36). In cod kidneys the mean length of 20 spores was 16.4 µm, (±2.5), the mean width 8.6 µm, (±1.8). In haddock kidneys the mean length of 20 spores was 11.8 µm, (±2.5), the mean width 6.3 µm, (±1.7). Squashes of fresh kidney tissue were made from 20 cod from our aquaria. Sixteen cod contained myxosporidia. The mean length of 20 spores examined by differential interference contrast microscopy was 22.0 µm, (±3.8), the mean width was 12.9 µm, (±2.4).

Microspora:- nodules of L. morhua:- in the head-kidneys of some inshore cod from Terence Bay (Morrison 1983).

4) DIGESTIVE TRACT (oesophagus, stomach, intestine, pyloric caeca)

Bacteria:- various species of Vibrio were isolated from the intestines of cod, haddock and witch flounder taken off Chebucto Head in the 1981 survey (Table 10). These are thought to be normal inhabitants of the gut of marine species. Vibrio species were also isolated from the intestines of herring from the Bay of Fundy near Deer Island, and Vibrio anguillarum from cod suffering from vibriosis in the Halifax aquarium (Table 11).

Rodlet cells:- often in the mucosa of oesophagus, intestine (Fig. 37) and pyloric caeca. Their appearance was the same in all these organs as well as the kidney of the same species.

Apicomplexa-Coccidia:- sporocysts, each containing two sporozoites, of unidentified coccidia in vacuoles in the intestinal epithelium of one silver hake (Table 1, Fig. 38) and one American plaice (Table 2, Fig. 39).

Playhelminthes - Digenea - Steganoderma formosum:- from the pyloric caeca of one flatfish.

- Cestoda - Clestobothrium crassiceps:- intestine of silver hake.

- Abothrium gadi:- intestine of cod and haddock, often with the anterior end in the pyloric caeca.

- Bubothrium sp. and plerocercoids:- intestine of redfish.

- Bothrimonus sturionis:- intestine of one flatfish, and Bothriocephalus scorpii:- intestine of two flatfish.

Acanthocephala - Echinorynchus sp. and Corynosoma sp.:- in cod, haddock, some pollock and a few flatfish.

Nematoda - Anisakis simplex (larval):- mesenteries, pyloric caeca and coelom of cod, haddock, silver hake, pollock, mackerel, flatfish and redfish.

- Hysterothylacium sp. (p.):- stomach and intestine of cod, haddock, silver hake, pollock, mackerel, flatfish and redfish.

In sectioned material, unidentifiable organisms (probably helminths) were found in the intestinal wall of one yellowtail flounder (Table 3, Fig. 40). Plerocercoids were often found in the lumen of the intestine close to or attached to the wall (Fig. 41) in cod, haddock, sea raven and mackerel (Tables 1-3). Larval platyhelminthes were found in the pyloric caeca of cod, haddock, herring, pollock, sea raven and silver hake (Tables 1-7, Fig. 42). The presence of plerocercoids and digeneans was confirmed in some fresh cod from our aquaria using squash preparations. A larger helminth was found in the lumen of one yellowtail intestine (Table 2). Nematodes were often found in the lumen and sometimes on the outer surface of the intestine and pyloric caeca of haddock (Fig. 43), cod, pollock (Fig. 44) and yellowtail flounders and American plaice (Tables 1-3). Nematodes were found in the stomachs of two pollock (Table 7).

Granulomas:- cysts with granulomatous centres surrounded by a fibrous layer were seen in the walls of the intestine and pyloric caeca of herring, haddock, pollock and redfish (Tables 1-3).

5) LIVER.

Livers varied considerably in the vacuolization of the hepatocytes (Fig. 45 and 46). These differences did not seem to be associated with any other changes observed in the fish.

Apicomplexa - Coccidia:- in 47/80 herring (Tables 2-6, Fig. 47), 5/14 silver hake (Table 1, Fig. 48) and 4/5 mackerel (Table 1, Fig. 49). The morphology of the unsporulated and sporulated oocysts of the coccidium Goussia clupearum in herring liver has been studied in some detail (Morrison and Hawkins 1984). The mean length of 20 spores in sectioned material was 10.8 µm, (±1.3), the mean width 6.8 µm, (±0.9). The coccidia in silver hake and mackerel do not appear to have been reported in the literature. They have thick-walled sporocysts each containing two sporozoites. The mean length of the spores in silver hake from 20 measurements was 10.2 µm, (±1.6). The mean width was 5.5 µm, (±0.5). The mean length of 20 spores in mackerel was 9.6 µm, (±0.8), the width 5.4 µm, (±0.4).

Myxozoa:- organisms which may be vegetative stages were found in bile ducts in one American plaice (Table 2).

Fungi:- Ichthyophonus hoferi:- in yellowtail flounders on the Scotian Banks. Sections of liver from infected fish showed cysts (Fig. 50) from which typical hyphae and sporangia were cultured (Fig. 51). This disease has been described in detail by Powles, Garnett, Ruggieri and Nigrelli 1968; Ruggieri, Nigrelli, Powles and Garnett 1970 and Hendricks 1972.

Nematoda:- larval Anisakis simplex in cod, haddock, silver hake, pollock, mackerel, flatfish and redfish (Table 8). In sectioned material one nematode, probably A. simplex, was found in the liver of one cod (Table 2).

Granulomas:- in the liver of one cod (Table 3).

6) GALL-BLADDER

Myxozoa:- Myxidium gadi:- in gall-bladders of 7/10 pollock from Grand Manan (Table 7, Fig. 52 and 53) and two haddock from the approaches to Halifax harbour examined in 1979. Severely infected gall-bladders were hard in consistency, had lost the normal single wall and had developed many lacunae filled with myxosporidia. Usually there were vegetative stages near the epithelial wall and spores in the lumen (Fig. 52). The spores, like those found in the kidney of cod and haddock, were elongate, with a polar capsule at each end (Fig. 53). The mean length of the spores in pollock from 40 measurements was 10.8 µm, ±1.2). The mean width was 3.9 µm, (±0.5). The mean length of haddock from 20 measurements was 10.3 µm,(±1.6). The mean width was 4.2 µm (±0.6).

7) SWIMBLADDER

Apicomplexa - Coccidia - Goussia gadi:- in lumen of swimbladder of cod and haddock (Table 1, Fig. 54). The mean length of 30 sporocysts from the swimbladder of the cod was 13.5 µm, (±1.2), the mean width 9.6 µm, (±0.9). The mean length of 10 sporocysts from the haddock swimbladder was 14.0 µm, (±1.3), the mean width 8.4 µm, (±1.2). The developmental stages were described by Fiebiger (1913), who obtained spore measurements of 12 µm long by 9 µm wide. The ultrastructure of the maturing stages was studied by Odense and Logan (1976).

8) HEART

Apicomplexa - Coccidia:- probably Goussia clupearum:- found in the heart musculature of one herring (Table 5).

Platyhelminthes - Digenea - encapsulated eggs and early larval stages of Aporocotyle simplex:- in the muscle of 8/12 hearts of American plaice (Tables 2 and 3, Fig. 56).

- Digenea - Metacercarian cysts:- in the cardiac muscle of two cod (Table 2). A metacercarian cyst was seen in the cardiac muscle of one haddock (Table 3, Fig. 55).

Nematoda:- in the lumen of the ventricle of one plaice heart (Table 3, Fig. 57).

9) GONADS

Apicomplexa - Coccidia - Eimeria sardinae:- found in the maturing and mature testes of 19/23 herring (Tables 3, 5, 6, Fig. 58). The structure of the unsporulated and sporulated oocysts has been studied (Morrison and Hawkins 1984).

10) MUSCLE AND SKIN

Viruses - Lymphocystis disease:- on one American plaice from the Southern tip of the Grand Banks off Newfoundland. We have not found this condition on flatfish from the inshore waters around Nova Scotia or the Scotian Banks.

Bacteria - Vibrio anguillarum and Aeromonas salmonicida, found in codfish from tanks at the Halifax laboratory, have already been listed under 3) Kidney, since the bacteria were cultured from this organ. Furunculosis caused by A. salmonicida resulted in open sores or furuncles on the skin surface (Cornick et al. 1984 and Morrison, Cornick, Shum and Zwicker 1984).

Yeast forming pink colonies in cultures tentatively identified as Rhodotorula sp. was associated with the pink color of the skin of a haddock from the Bay of Fundy near Deer Island, N.B.

Microspora - elongate white nodules about 1 cm long of Pleistophora hippoglossoides:- found between the muscle bundles in American plaice, especially around the body cavity. In sections for light microscopy this microsporidian could be recognized by the groups of parasites in varying stages of development from the multinucleate plasmodium to spores, each group surrounded by a pansporoblast membrane (Fig. 59). These parasites did not seem to infiltrate the surrounding muscle fibres, and were often engulfed by host macrophages at the periphery of the nodule. The structure of this parasite has been studied in detail (Morrison, Harryatt and Gray 1984).

Platyhelminthes - Digenea - Metacercarian cysts:- Stephanostomum baccatum:- (Fig. 60) in large numbers in the submucosa of the skin of many flatfish, especially inshore American plaice. Mainly on the ventral surface.

- Digenea - Metacercarian cysts:- probably Cryptocotyle lingua:- surrounded by melanocytes in the submucosa of the skin of various fish including cod (Fig. 61), haddock, pollock and mackerel. These cysts occurred in such large numbers in one cod that it was apparently blinded, and turned black in color.

- Digenea - Didymozoid trematode, probably Halvorsenius exilis (Gibson, MacKenzie and Cottle 1981):- golden threads 1-1.5 cm long were observed running parallel to the muscle fibres in a mackerel submitted by a fisherman from the Halifax area. Squashes and histological sections showed that these were sacs of spermatozoa and eggs, and somatic tissue (Fig. 62). Only fragments of specimen could be removed from the muscle tissue for examination.

Nematoda - Pseudoterranova (Phocanema) decipiens (larval):- found in the fillets and napes of cod and flatfish.

Arthropoda - Sphyrion lumpi:- on redfish (Odense and Morrison 1978).

Melanism:- black patches were often found in the flesh of redfish (Odense and Morrison 1978) by workers filleting fish at the National Sea Plant in Lunenburg. Microscopically, all that could be found were accumulations of melanocytes (Fig. 63).

Meningioma (?):- large white lumps were noted in some cusk being filletted by fish-plant workers at Lockport, N.S. One was tentatively identified as a meningioma or possibly hemangiopericytoma (Dr. J.C Harshbarger, personal communication).

11) PSEUDOBRANCH

Tumor or X-cell lesion:- beneath the pseudobranch of 86/4,256 cod (Fig. 64). The prevalence of this tumor was about 2%, being usually higher (up to 4.7%) near land, and lower (about 0.9%) on the Scotian Banks (Morrison, Shum, Appy, Odense and Annand 1982).

12) BLOOD SMEARS

Inclusions in erythrocytes:- found in haddock, silver hake, pollock, herring, mackerel, flatfish and redfish (Fig. 66). May be viral erythrocytic necrosis (V.E.N.) (Snail 1982).

Apicomplexa: - probably Haemogregarina aeglefini:- found in haddock, silver hake, mackerel, redfish and one flatfish (Table 8, Fig. 65).

DISCUSSION

There are obvious problems associated with attempts to study disease in marine fish. Groundfish are trawled then brought up rather rapidly from the sea-bottom, resulting in pressure changes which often produce some obvious gross changes such as eversion of the stomach, but also probably microscopic abnormalities. Compression of fish in the cod-end when fish are caught by trawling probably also results in tissue damage, although this was minimized as far as possible by limiting tows to five-minutes. Gill aneurysms may result in part from poor fixation since more were found

in the gills collected on the 1980 cruise than on later cruises where samples were more carefully fixed. Rough weather conditions often made dissection and fixing difficult. We found that the most satisfactory procedure, especially for samples destined for electron microscopy, was to bring back the fish in live-holding tanks and work on them in the laboratory. This was only possible when the temperature of the surface water was fairly low, the travelling time was limited to a few hours and the fish had not been damaged by decompression. Limited effort could be expended on this study, so only a few specimens of each fish species were taken at each location. This was not adequate to permit detection of infestations of low prevalence.

Damage resulting from decompression, compression in the cod-end and poor fixation cannot be counted as abnormalities, but the presence of parasites, and of tissue changes such as hyperplasia and fusion of gill lamellae would not be affected by these conditions. As might be expected, the highest percentage of abnormalities was found in gills, which are the most delicate tissues exposed to pollution and parasites in the aquatic environment.

Marine fish can store large amounts of lipid in the liver (Borgstrom 1961; Bucke et al., 1984). The fatty appearance of some livers, for example those of pollock, should probably not be considered pathological. Melano-macrophage centres have been described in many species (Agius 1980, Bucke et al. 1984). It was found (Agius 1980), as in this study, that advanced teleosts have discrete centres whose appearance varies in different species, and that centres were more evident in the kidney and spleen than in the liver. Herring and gaspereau are more "generalized" fish, (Leim and Scott 1966), and, like salmonids (Agius 1980), might be expected to have less discrete centres. Individual fish, as described in this account, varied in the number of centres in their tissues (Bucke et al. 1984). There did not seem to be an increase in size or number of centres in fish with parasites in the spleen or elsewhere in the body, although these centres are believed to have an immunologic role (Groman 1982).

There is much literature on the coarse eosinophilic leucocytes recorded in the present study (Groman 1982). They are presumed to be host cells, but their function is undetermined. We did not find any relationship between prevalence or intensity of these cells and occurrence of abnormalities. It is still not known whether the rodlet cells found in many epithelia are host cells or separate organisms.

Studies of parasites from the 1980/81 Marine fish surveys were severely limited. As only fixed and frozen material was available for study tissue squash preparations were not possible. Because of the highly volatile and toxic nature of the fixative, preserved gills and viscera were examined at arms length, under a fume hood and only the larger more conspicuous helminths were detected. Detection of many enteric helminth and protozoan species would have required microscopic inspection of the gut wall and gut contents. Some of this information was obtained from examination of sectioned material. A total of only 175 fish bodies were saved and frozen. Smaller parasites in the flesh such as metacercaria were not examined microscopically.

A list of parasites reported from fish in Canada can be found in Margolis and Arthur (1979). Studies on fish parasites around Nova Scotia include those of Appy (1979) and Appy and Burt (1982) on parasites of cod. Bray (1979) worked on the digenea of various marine fish, Scott (1981) studied haddock parasites and McGladdery (1982) herring parasites. McClelland et al., 1983a and b; 1985, surveyed the prevalence and intensity of infection of the "sealworm" Pseudoterranova (Phocanema) decipiens (Krabbe 1878) Gibson and Colin 1982 and the "herringworm" Anisakis simplex (Rudolphi 1809, det. Krabbe 1878) and Contracaecum osculatum in cod and American plaice. McClelland and co-workers also worked out a possible life-history of the sealworm (McClelland 1982, McClelland et al. 1983a).

When specimens taken for bacteriological studies were plated onto culture media on board ship contamination resulted, but contaminant-free cultures could be obtained by bringing back frozen samples and culturing them in the laboratory. Results were negative on all fish surveys, and diseases such as ulcers and fin-rot which have been found on marine fish in other areas, for example the ulcus syndrome found in cod from Danish Waters (Jensen 1983) were lacking. Murchelano and Azarovitz (1979) observed similar conditions in a microbiological survey of groundfish from the western north Atlantic. They suggested that whereas the isolated groundfish stocks were relatively free from disease, stocks in estuarine, pollution-affected areas might have a higher prevalence of disease. Thus, the sampling program was changed in 1981 to concentrate on inshore herring stocks which might be exposed to more pollution. The results were uniformly negative for bacterial and viral pathogens.

Death of fish from bacterial infections in our laboratory live-holding tanks probably occurred because of stress from such factors as crowding or inadequate diet.

NEW RECORDS

In this report we describe some organisms which have not, to our knowledge, been previously reported. Others are described in new hosts.

These are:-

1) Prokaryote organisms:- these have rarely been described in marine finfish, and not previously in the hosts listed in this account. Inclusions with a similar appearance under the light microscope were found in carp gills (Hoffman, Dunbar, Wolf and Zwillenberg 1979), and described as epitheliocystis disease. Using electron microscopy it was found that these bodies contained rickettsias, and it is now known (Paperna, Sabnai and Zachary 1981; Molnar and Boros 1981) that these organisms are widespread in finfish as well as in other animals. Paraffin sections of prokaryote inclusions can be re-embedded in resin in order to identify the organisms. Although ultrastructural detail is better observed after fixation and embedding appropriate for electron

microscopy, there is, even after re-embedding paraffin sections, enough detail to classify the organism as a mycoplasm, epitheliocystis, or as a member of the rickettsiales or chlamydiales. In this way we were able to identify the sea-raven inclusion as epitheliocystis.

2) Bacteria:- Aeromonas salmonicida infection of cod. This is the first time that an epizootic associated with this organism has been reported in cod.

3) Viruses:- Infectious Pancreatic Necrosis Virus in cod. This is the first time, to our knowledge, that this viral fish pathogen has been isolated from this species. The agent, which normally kills young salmonids, is being increasingly isolated in non-salmonid fish.

4) Sarcomastigophora - Ichthyobodo sp:- this organism has been recorded in salmonids, Gasterosteus aculeatus (Margolis and Arthur 1979), winter flounder, Pseudopleuronectes americanus (Walbaum), and plaice Pleuronectes platessa (Cone and Wiles 1984). This is the first record of Ichthyobodo in haddock, Melanogrammus aeglefinus.

5) Ciliophora-Trichodinids:- these have been frequently described on various species of fish (Margolis and Arthur 1979) but not previously on cod, mackerel or yellowtail flounder.

6) Apicomplexa-Coccidia:- Goussia clupearum has been described in the liver of herring, and Eimera sardinae in the testis, but not, previously, at the ultrastructural level. There have been no previous reports of coccidia in the livers of silver hake, mackerel or gaspereau, or in the kidneys of haddock or cod. The coccidian in haddock and cod kidney has smaller spores than those of G. gadi, and the coccidians in silver hake and mackerel livers have smaller spores than those of G. clupearum in herring. These coccidia may be new species.

- Haemogregarinidae:- Haemogregarines have not previously been reported in silver hake, mackerel, flatfish or redfish from eastern Canada.

7) Myxosporea:- the myxosporidia Myxidium bergense and M. gadi have both been reported in the gall bladders of the haddock (Margolis and Arthur 1979). Myxosporidia have not been reported in the the gall-bladders of pollock, nor in the kidneys of either cod or haddock. The shape of these spores and position of the polar capsules are similar to those of Myxidium bergense and M. gadi. The sizes of the spores in haddock gall bladders are as follows:

	Length of spore (µm)	Width of spore (µm)	Reference
M. bergense	16.2-19	7-9	Kudo, 1920
	16 -18	6-7	Mavor, 1915
	16 -19	8	Ellis, 1930
M. gadi	6(?)-14	4-6	Kudo, 1920

The spore sizes of the myxosporidia described in this account are as follows:-

Host	Tissue	Length of spore (µm)	Width of spore (µm)
Pollock	Gall-bladder	x = 10.8±1.2	x = 3.9±0.5
Haddock	Gall-bladder	x = 10.3±1.6	x = 4.2±0.6
Cod	Kidney	x = 16.4±2.5	x = 8.6±1.8
(from fresh material		x = 22 ±3.8	x = 12.9±2.4)
Haddock	Kidney	x = 11.8±2.5	x = 6.3±1.7

The myxosporidia found in the gall-bladders of haddock and pollock appear, on the basis of spore size and morphology, to be M. gadi. The larger spores found in cod kidney could be Zschokkella hildae Auerbach. The spores found in haddock kidney are intermediate in size, although closer to those of M. gadi. Detailed study of fresh material is probably required for precise identification.

8) Platyhelminthes:- to our knowledge the reports of plerocercoids in redfish, pollock, sea raven and silver hake are new. Aporocotyle simplex had previously only been described in the mesenteric vessels of American plaice from the Atlantic region (Margolis and Arthur 1979). Didymozoid trematodes have not previously been reported from mackerel from the Western Atlantic.

9) Nematoda:- Hysterothylacium sp.(p) does not appear to have been previously reported in pollock.

Many of these parasites have not previously been reported because they are too small for gross observation, and often occur in organs which cannot be studied using squash preparations, so that histological techniques have to be used. Often, also, ultrastructural techniques were needed for complete identification.

Epidemic diseases of marine fish do occur, although they are often difficult to document. These diseases are reviewed by Munro, McVicar and Jones (1983). We have not done the studies required to determine whether mortalities result from the parasites described in this account. It might be suspected that, for example, cod with cysts of Loma morhua spread throughout their organs, American plaice with numerous eggs of Aporocotyle simplex in the gills and heart, or pollock with gall-bladders packed with myxosporeans would be more susceptible to other stresses. Eimera sardinae has been reported to cause castration of males of Sardina pilchardus (Pinto 1956), so parasite induced sterility may help to explain some stock fluctuations in herring. Other cases may have relevance to aquaculture. For example, wild cod might act as "carriers" of furunculosis, raising the possibility that they could affect salmonids in cage-culture. Ichthyobodo sp. has caused serious losses in marine salmonid farms off the coast of Norway (I.C.E.S. 1984) and Scotland (Ellis and Wootten 1978). The dimensions of the Ichthyobodo we found in haddock are similar to those of I. necator from salmon, so could be the same species. The pathological changes described by Ellis and Wootten in salmon smolts were not found in haddock, which might act as "carriers" of these parasites forming a possible reservoir of infection for caged salmonids in sea-water. The discovery of Ichthyobodo in haddock as well as in flatfish indicates this parasite might be more widespread in marine fish than previously realized. Epitheliocystis has also

caused serious problems in marine aquaculture (Paperna, Sabnai and Zachary 1981), and again the American plaice could act as a reservoir of infection for cultured fish. In the new genus Loma (Morrison and Sprague 1981 a,b, and c, and 1983) are microsporida which invade cod, haddock, brook trout Salvelinus fontinalis (Mitchill) and rainbow trout Salmo gairdneri Richardson. Although we have given the Loma sp. invading brook and rainbow trout different specific names from the species invading cod and haddock, we have not yet carried out infection studies, and there is enough morphological similarity between the species that they might be the same organism. So far we have only found one instance of infection of brook trout by microsporida, and none of rainbow trout in Nova Scotia, but the possibility exists of infection from marine fish hosts. Loma sp. caused an epizootic resulting in 10% mortality of juvenile chinook salmon at a hatchery in Alaska (Hauck 1984). The occurrence of L. morhua in many tissues in some specimens (Morrison 1983) indicates that this parasite could also have an effect on the health of the host.

This account describes the results of some small, incomplete surveys. However, the study indicates how little is known of diseases in wild marine fish, how commonly these fish are parasitized, and how much more information needs to be gathered before we know which diseases could be passed on to cultured fish, and which may contribute to stock fluctuations in the wild.

ACKNOWLEDGEMENTS

We thank the various short-term employees who did most of the technical work for this report. These include Inka Milewski, who did a careful examination of many of the slides, Robert Zwicker, who collected many of the specimens, Lance Robertson, and Brenda MacDonald. Vivian Marryatt completed the technical work for histology, and Betty Zwicker carried out most of the bacteriological work. We also thank Dr. J.S. Scott, Chris Annand, Daryl Lyon (port observer) and various technicians and fishermen for supplying samples. Dr. J. Thulin checked the identification of parasites in some of our micrographs, and identified Aporocotyle simplex in our sections of American plaice gill and heart.

We also thank Vikki Clayton for her careful work and patience in typing this manuscript, and Dr. J.S. Scott, Dr. D.K. Cone and Dr. D.J. Scarratt for carefully reviewing this manuscript.

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CAPTIONS

Figures are light micrographs of paraffin sections stained with haematoxylin and eosin, unless otherwise specified.

Figure

1. Herring gill. The pillar cells holding the thin epithelial lining of the lamellar blood sinus appear to have given way allowing blood cells to accumulate in the lamellae. These aneurisms, probably a result of poor fixation, were common in fish gills of various species. Bar = 0.1 mm.

2. Cod gill. The lamellar wall is thickened in two adjoining lamellae, so that little gas diffusion between the sea water and the lamellar blood sinus can take place. These lamellae have fused along part of their length. Mucous cells (M) occur on the lamellar surface as well as in their usual position at the bases between the lamellae. Bar = 0.1 mm.

3. Redfish gill. Numerous elongate prokaryote organisms can be seen in this basophilic inclusion in a lamella. P - pillar system. E - epithelium of lamella. Bar = 50 µm.

4. Herring gill. Feulgen-picromethyl blue stain. Densely-staining prokaryote inclusions can be seen in two lamellae. Bar = 50 µm.

5. Sea raven gill. Small prokaryote organisms can be seen in this inclusion. Bar = 50 µm.

6. Above specimen re-embedded in resin. Electron micrograph. Several organisms surrounded by a double membrane can be seen. Since they are of a similar shape and size, sometimes with increased density in the centre, they are probably epitheliocystis organisms. Bar = 0.3 µm.

7. American plaice gill. Semithin resin section. Toluidine blue. Mucous cells (M) and an inclusion (I) consisting of many small organisms enveloped by host fibroblasts can be seen at or near the epithelial surface. There is also an early developmental stage of Aporocotyle simplex (AS). Bar = 30 µm.

Figure

8. Inclusion in American plaice gill. Electron micrograph. Many small rounded organisms, each with a central nucleoid, can be seen. This morphology indicates that these are epitheliocystis organisms. The host cell containing these organisms has become modified, containing numerous mitochondria (Mi) and tubules. This cell is enveloped by elongate, fibroblast-like cells (F). Bar = 1 µm.

9. Haddock gill. An inclusion containing numerous spores of Loma morhua can be seen at the tip of a gill lamella. Similar inclusions were seen at the base of lamellae and within the gill filament. Bar = 50 µm.

10. Haddock gill. Electron micrograph. Various stages (sporont - Sp, sporoblasts - Sb, spore - S) in the development of the microsporidian Loma morhua can be seen. The host cell is hypertrophied, and its cytoplasm contains many vacuoles, mitochondria (Mi) and profiles of Golgi apparatus (G). The plasmalemma is deeply invaginated, although these invaginations (In) do not extend into the region containing parasites. Bar = 2 µm.

11. Mackerel gill. Two trichodinids (T) with a central macronucleus can be seen. The aboral cilia (C) are visible on one of these organisms. Bar = 20 µm.

12. Yellowtail flounder gill. An organism (?) of similar shape and size to a trichodinid (T) is closely apposed to the lamellar surface. The nuclear structures are unusual, and aboral cilia cannot be distinguished. Bar = 20 µm.

13. Cod gill. Trichrome stain. Three trichodinids showing denticles (D) and aboral cilia (C) can be seen between the lamellae. Bar = 50 µm.

14. Cod gill. Scanning electron micrograph. A trichodinid with cilia (C) around the outer edge of the aboral surface can be seen between two lamellae (L). Bar = 20 µm.

15. Haddock gill. Several Ichthyobodo sp. can be seen attached to the interlamellar epithelium. Bar = 20 µm.

16. American plaice gill. Numerous eggs and early developmental stages of Aporocotyle simplex (AS) can be seen. Some of these are surrounded by a fibrous capsule of host cells. Bar = 0.1 mm

17. American plaice gill. Semithin resin section. Toluidine blue. Two eggs of Aporocotyle simplex can be seen. Both contain vitelline cells (V), and a central developing embryo (Em). The eggs are surrounded by a capsule (Ca). Bar = 20 µm.

18. Cod gill. A metacercarian cyst is embedded in the connective tissue of the gill filament. Bar = 50 µm.

19. Haddock gill. The nodule contains an oocyte-like body with many vesicles (Ve) in the centre, surrounded by a capsule (Ca). Nodules in other specimens varied in the number of vesicles. Outside the capsule is a layer of densely packed host fibroblasts (F). In some specimens macrophages were also present. Bar = 0.1 mm.

20. Cod gill. This multicellular organism appears to have muscle bundles and an organelle (O) which may be an eye-spot. There is an organ attaching the organism to the gill lamella. It would appear to be a small arthropod, possibly a copepod. Bar = 50 µm.

21. Cod gill. This multicellular organism does not show the well-defined structures seen in the organism in Fig. 20. There does, however, seem to be a special structure attaching it to the gill lamella. Bar = 20µm.

22. Silver hake gill. The suckers (Su) and hooks (H) of the opisthaptor attaching a trematode to the gill filament can be seen. This trematode is probably Anthocotyle merluccii. Bar = 0.3 mm.

23. Haddock spleen. There are several small blood arterioles in the centre of ellipsoids (El), and several melano-macrophage centres (MM) with small amounts of melanin. Bar = 0.1 mm.

24. Silver hake spleen. An arteriole (Ar) at the centre of an ellipsoid and a small melano-macrophage centre with a large amount of dark melanin are present. Bar = 50 µm.

25. American plaice spleen. Several arterioles (Ar) surrounded by white pulp (W) forming ellipsoids are present, as well as small melano-macrophage centres (MM). The melanin appears paler in this micrograph than in Figs. 23 and 24 because most of it is a yellowish colour. Bar = 0.1 mm.

26. Silver hake spleen. The thick cuticle (Cu), longitudinal muscle bundles (MB) and part of the digestive tract (DT) of this nematode can be recognized. Bar = 0.2 mm.

27. American plaice head kidney. There is a well defined, light-staining region of adrenal tissue. Bar = 0.3 mm.

28. Haddock kidney. Two melano-macrophage centres are present, similar in appearance to those in the spleen (Fig. 23). A glomerulus (Gl) and many kidney tubules are present amongst the haemopoietic tissue. Bar = 0.1 mm.

29. Cod kidney. There are many rodlet cells (RC) aligned with the columnar epithelial cells of this mesonephric duct. Bar = 50 µm.

30. Cod kidney. Semi-thin resin section. Toluidine blue stain. Many coccidia, probably the zygote stage, can be seen in these kidney tubules. There is a central nucleus with circular nucleolus in each zygote, and many amylopectin granules can be seen in the cytoplasm. The oocyst membranes (OM) are thin and fragile, and cannot be easily distinguished in this micrograph. There may be one zygote (Z) between the epithelial cells lining one tubule. Bar = 20 µm.

Figure

31. Haddock kidney. In the kidney tubule are one coccidian zygote (Z) and several groups of sporoblasts (SB). When focussing up and down through the section, it can be seen that the sporoblasts are in groups of four. Bar = 20 µm.

32. Haddock kidney. This group of coccidians consists mainly of pairs of sporozoites (SZ) in sporocysts. Bar = 20 µm.

33. Cod kidney. Fibroblasts have accumulated around these coccidia, mainly sporocysts, to form a granuloma. Bar = 20 µm.

34. Cod kidney. Numerous vegetative stages and spores of a myxosporidian can be seen in this mesonephric duct. Bar = 0.1 mm.

35. Cod kidney. Two elongate spores (S) with a polar capsule (PC) at each end can be seen between other developmental stages of this myxosporidian. Bar = 20 µm.

36. Cod kidney. Squash preparation, differential interference contrast. In this myxosporidian spore the two polar capsules containing coiled polar filaments (PF) can be seen. Bar = 10 µm.

37. Silver hake intestine. Several rodlet cells (RC) are oriented parallel to the epithelial cells lining the intestine. Bar = 20 µm.

38. Silver hake intestine. Sporocysts, one containing two sporozoites (SZ) occur in oocysts between the epithelial cells. Bar = 20 µm.

39. American plaice intestine. A group of small sporocysts, one demonstrating two sporozoites (SZ), are situated between the epithelial cells. Bar = 20 µm.

40. Silver hake intestine. Three small multicellular organisms (MO), presumably larval helminths, can be seen in the epithelial layer. There is a cross-section of a helminth to the left which can be seen to have spines (Sp) when focussing up and down through the section, so is probably an acanthocephalan (Ac). Bar = 50 µm.

41. Cod intestine. Three of the suckers (Su) of this plerocercoid are embedded in the epithelium. Bar = 30 µm.

42. Mackerel pyloric caecum. Several larval cestodes or trematodes can be seen. Some have suckers, so can be identified as plerocercoids. Bar = 0.1 mm.

43. Haddock intestine. A nematode is shown in cross section with a prominent cuticle (Cu). Bar = 0.3 mm.

44. Pollock pancreas (between pyloric caeca). This is a cross-section of a nematode showing the pharynx (Ph), somatic muscle (SM), and cervical alae (CA). Bar = 0.2 mm.

45. Haddock liver. Most of the cells have densely staining contents. Bar = 0.1 mm.

46. Haddock liver. This liver appears pale because the cells are highly vacuolized. Bar = 0.1 mm.

47. Herring liver. Many coccidian oocysts (CO), are present, often in clusters. Bar = 1 mm.

48. Silver hake liver. Several oocysts contain sporocysts with two sporozoites (SZ). Bar = 20 µm.

49. Mackerel liver. A group of oocysts contain sporocysts with two sporozoites, as in Figure 48. Bar = 20 µm.

50. Yellowtail flounder liver. Numerous cysts of Ichthyophonus hoferi can be seen. Groups of cysts are surrounded by host fibrous tissue, with normal liver tissue (Li) between. Bar = 0.4 mm.

51. Ichthyophonus hoferi culture from yellowtail liver. Hyphae (Hy) and sporangia have grown from the same type of cysts demonstrated in Figure 50. Bar = 0.3 mm.

52. Pollock gall-bladder. Brown and Brenn stain. The gall-bladder normally has a single wall. This portion of a gall-bladder shows that it is traversed by trabeculae (Tr). In the cavities between the trabeculae are numerous spores (S) and vegetative stages (V.S.) of myxosporidia, probably Myxidium gadi. Bar = 1 mm.

53. Detail of Figure 52. Several elongate spores with a polar capsule (PC) at each end can be seen. Bar = 20 µm.

54. Haddock swim-bladder. Sporocysts of Goussia gadi, each containing two sporozoites (SZ) can be seen. Bar = 50 µm.

55. Haddock heart. A metacercarian cyst surrounded by a fibrous capsule is present between the heart muscle fibres. Bar = 50 µm.

56. American plaice heart. Numerous eggs and early developmental stages of Aporocotyle simplex (AS), most encapsulated by host fibrous tissue, can be seen in the heart musculature. Bar = 0.3 mm.

57. American plaice heart. The cuticle (Cu) and digestive tract (DT) can be recognized in this nematode found in the lumen of the ventricle. Bar = 0.3 mm.

58. Herring testis. Squash preparation. Phase contrast illumination. Three oocysts of Eimeria sardinae, each with four sporocysts containing two sporozoites (SZ) are shown. Bar = 30 µm.

59. Pleistophora hippoglossoideos from American plaice. Plasmodia (Pl), segments (Se) produced by division of these plasmodia and mature spores (S) can be recognized. Each group of organisms, at the same stage of development, occurs in a packet bounded by the pansporoblast membrane (PM). Bar = 20 µm.

Figure

60. Squash preparation of metacercariae of Stephanostomum baccatum. Rows of spines (Spi) can be seen on the cuticle of these metacercariae, especially near the oral sucker. The ventral sucker (Su) is also visible. One metacercaria is still partly encapsulated, although the cyst (Cy) has split open. Bar = 0.3 mm.

61. Skin near eye of cod. Several metacercarian cysts can be seen in the connective tissue beneath the stratified squamous epithelium. Many melanocytes (Me) are associated with these cysts. Bar = 0.1 mm.

62. Section through organism, probably trematode, in mackerel fillets. Somatic tissue (S.T.), oocytes (Oo) and sperm (Spm) can be distinguished. Bar = 50 µm.

63. Section through fillet of redfish. A group and also single melanocytes (Me) can be seen between the muscle fibres. Bar = 0.1 mm.

64. Gross photograph of pseudobranch tumor (P.T.) under operculum (Op) in cod. The tumor forms a cream-colored mass, with an intact pseudobranch (Ps) on the surface.

65. Blood smear from silver hake. Giemsa stain. A haemogregarine, probably Haemogregarina aeglefini (HA), can be seen in one erythrocyte. Bar = 10 µm.

66. Blood smear from haddock. Giemsa stain. Inclusions (I), possibly viral erythrocytic necrosis, can be seen in three erythrocytes Bar = 10 µm.

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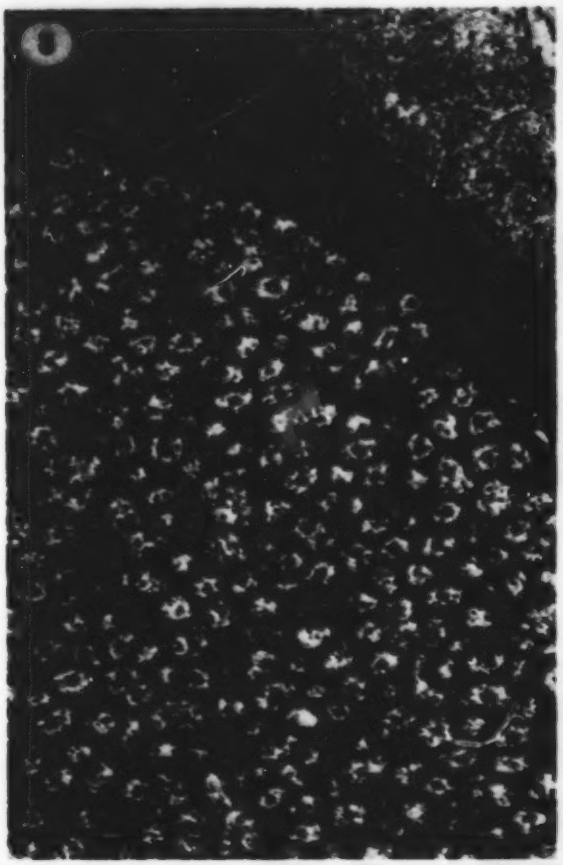

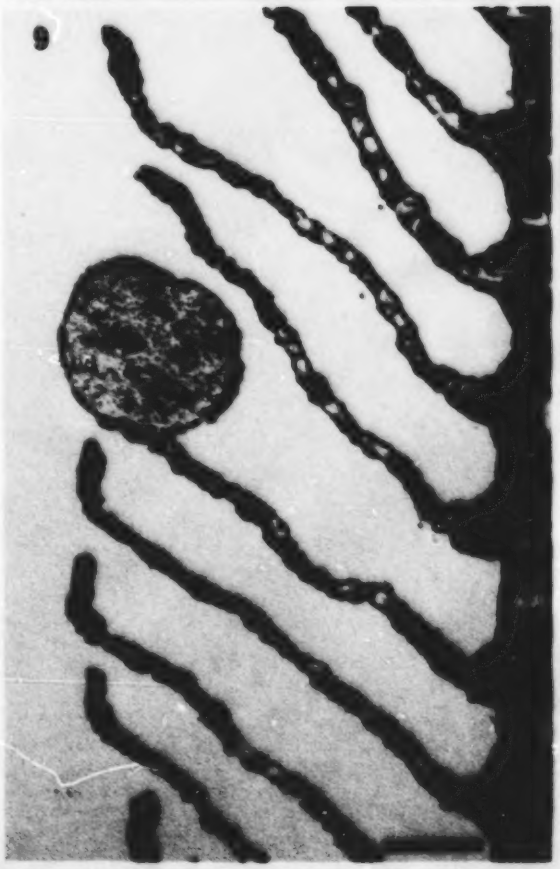

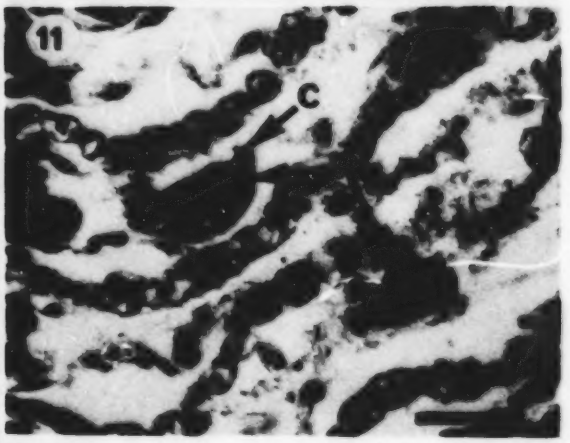
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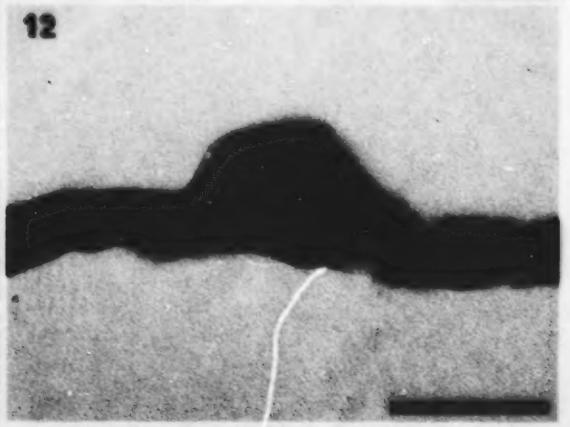

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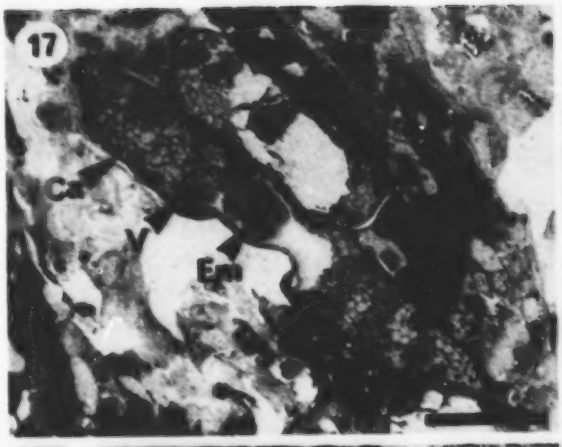
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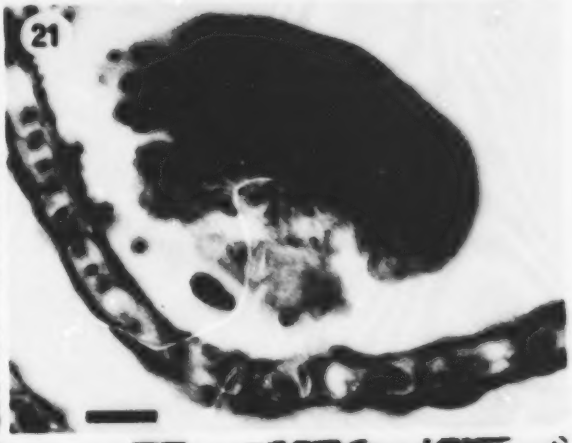
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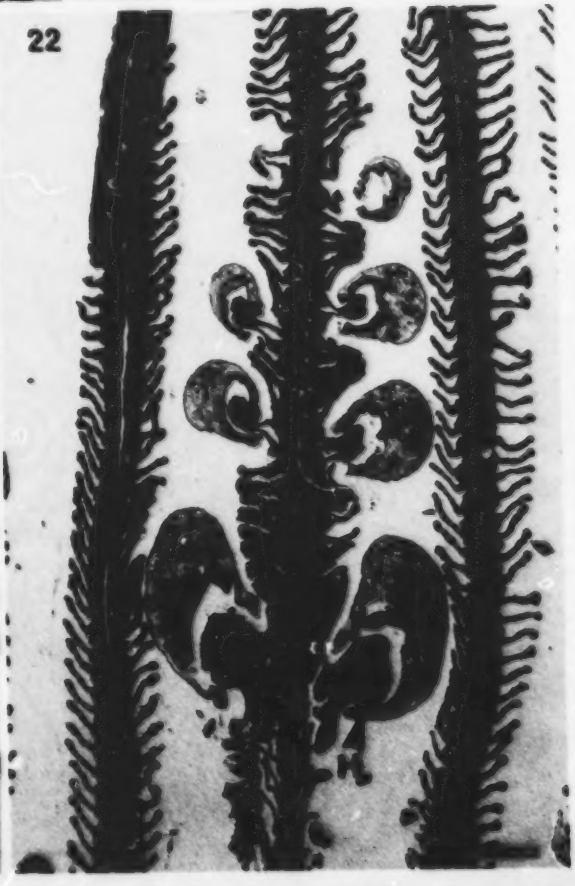
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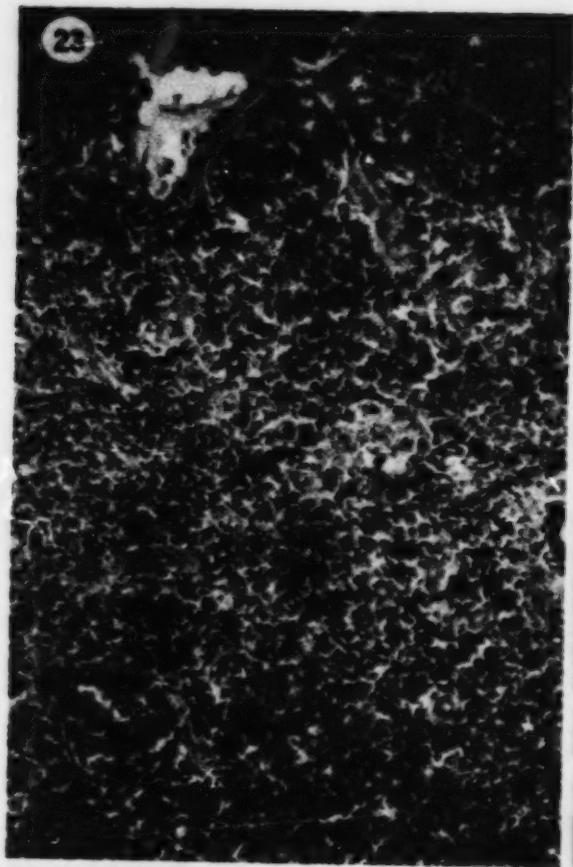

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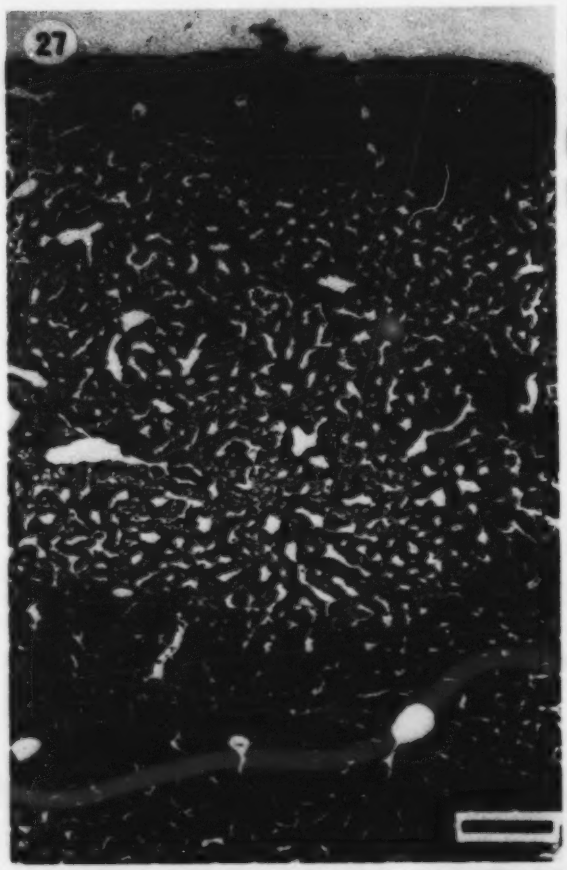
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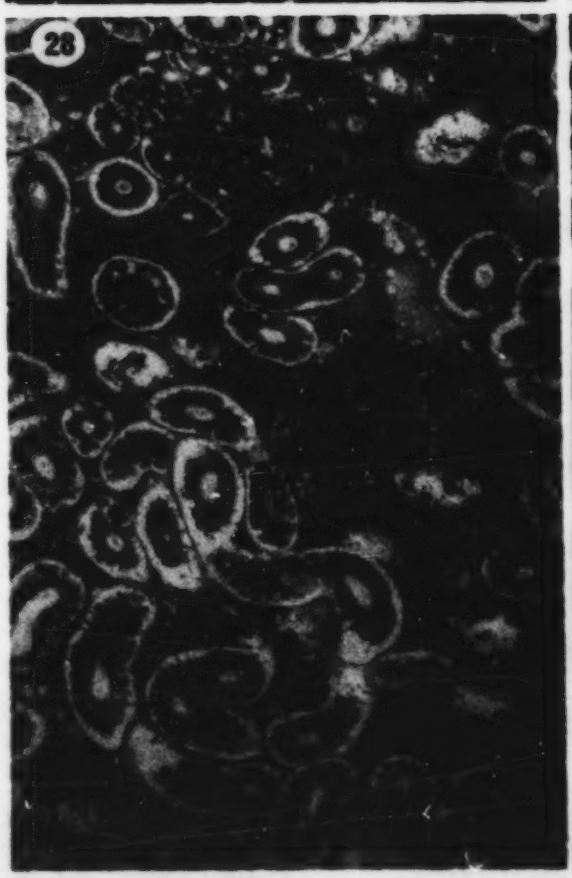
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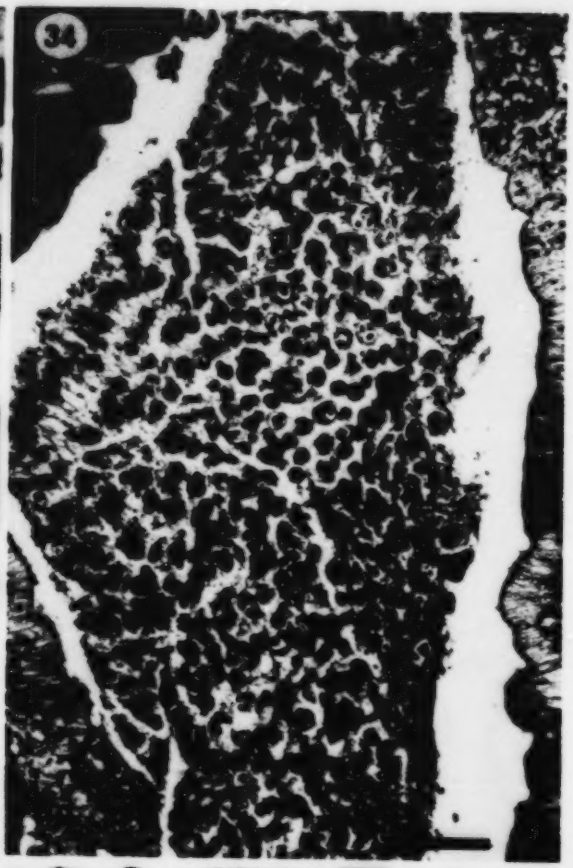
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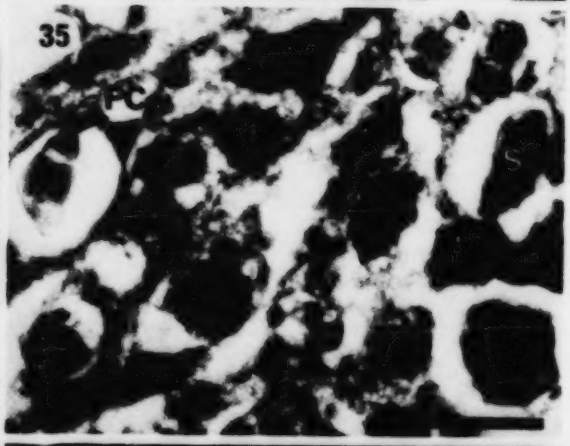
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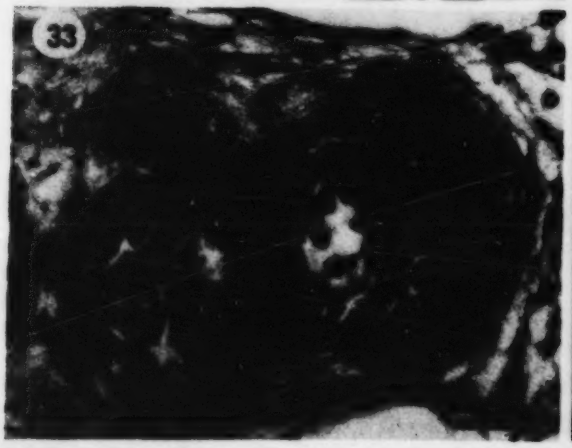
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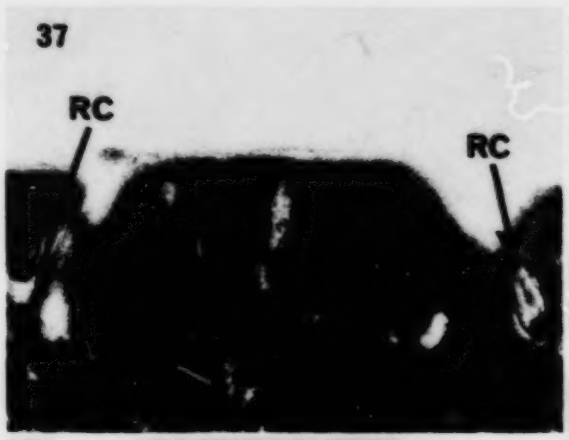
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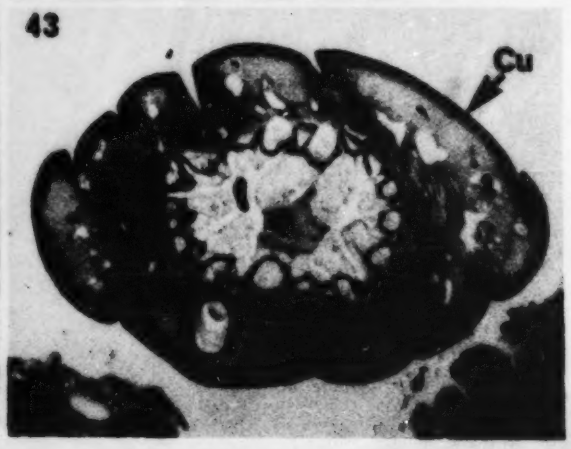
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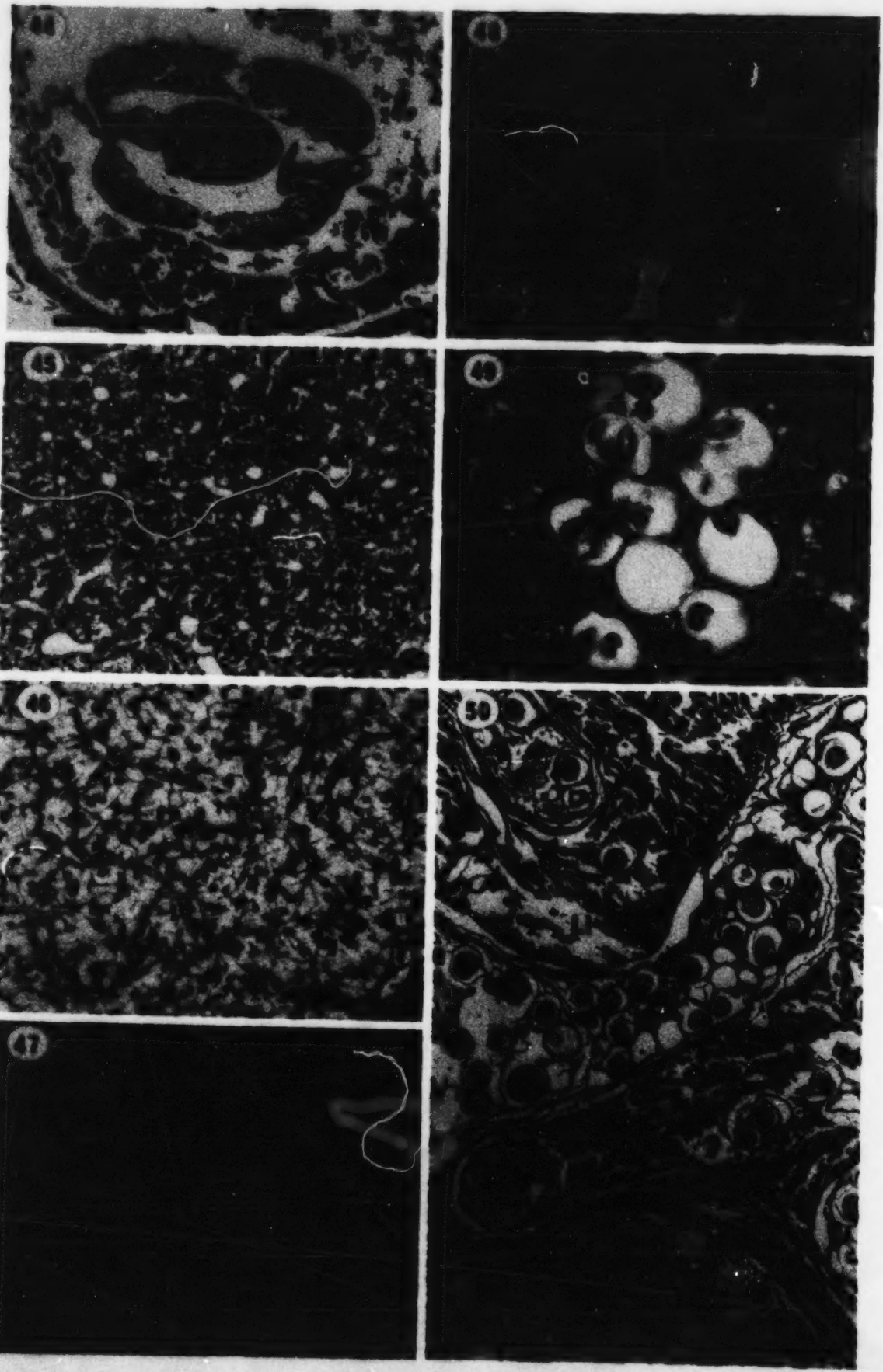
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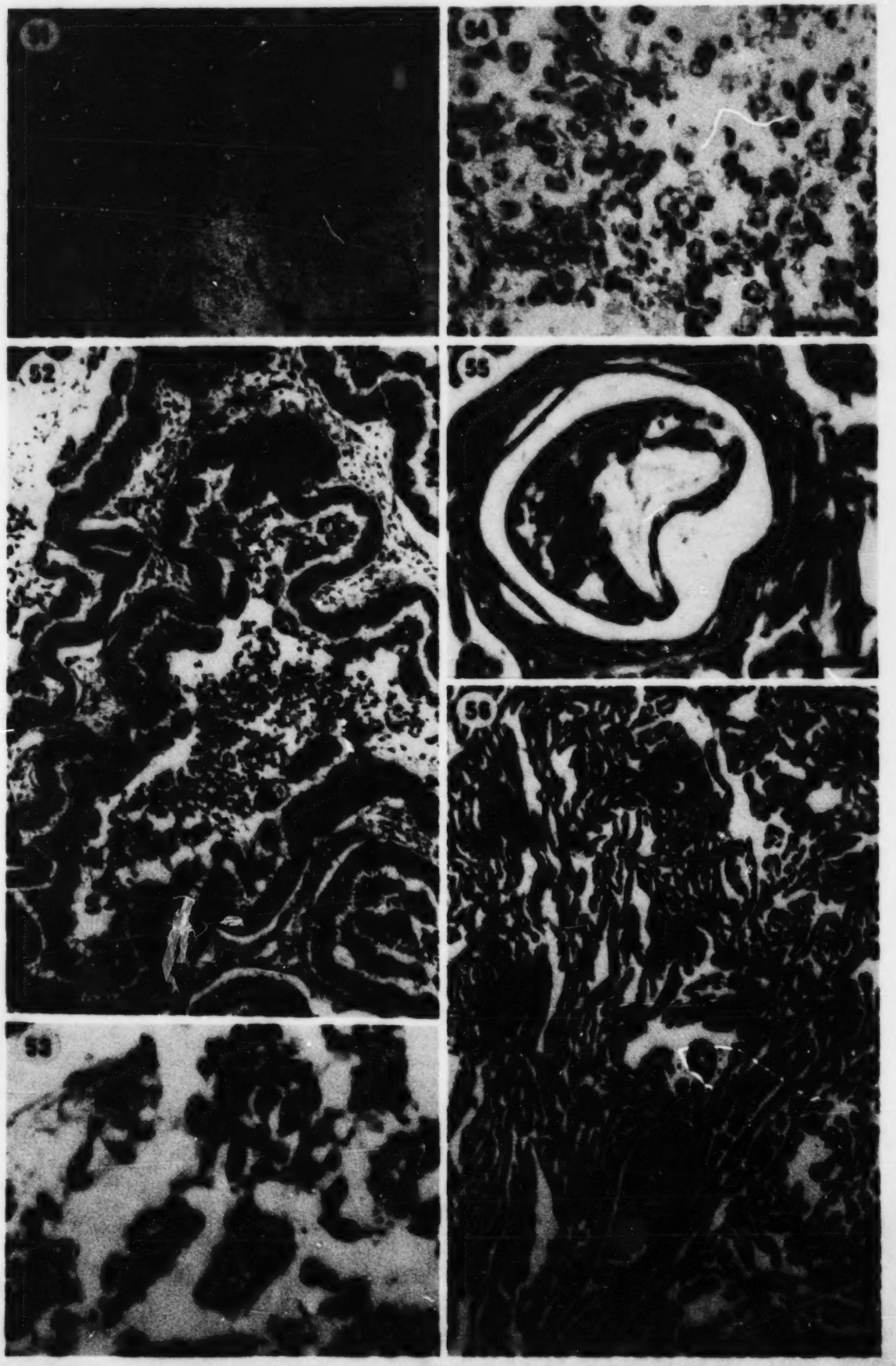
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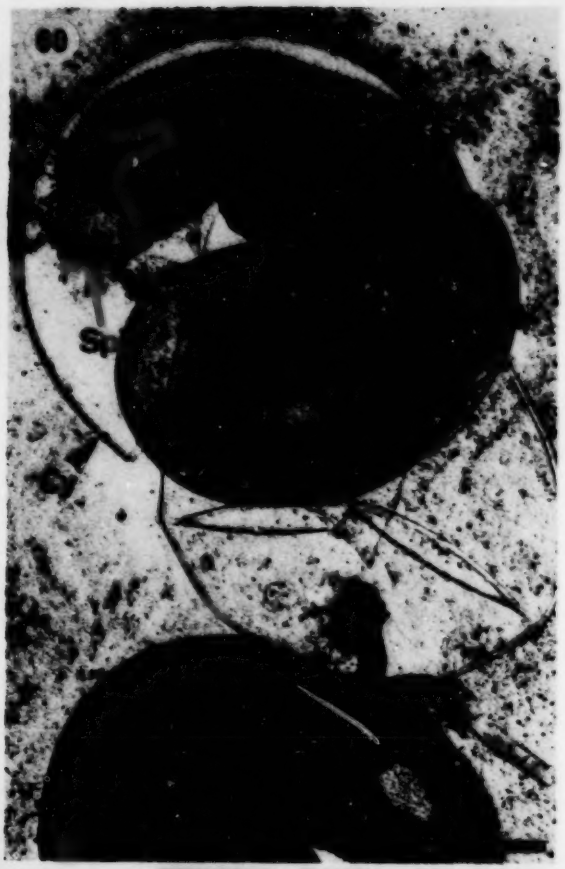
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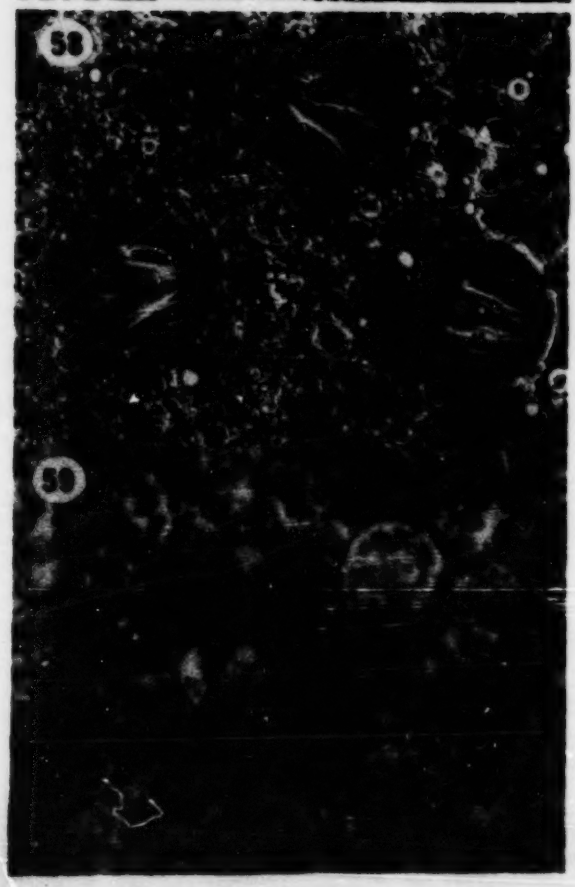
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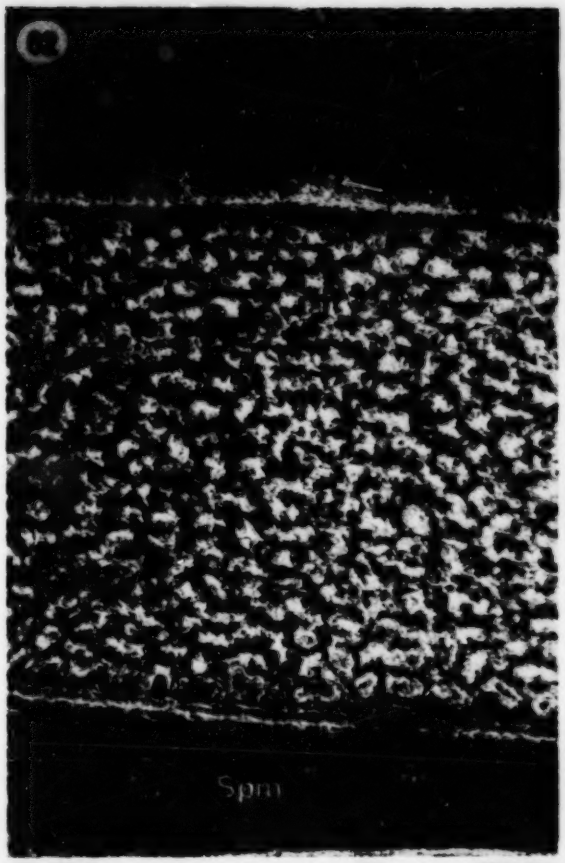
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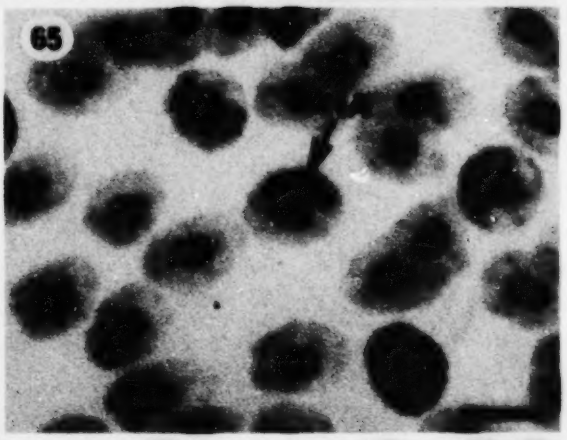

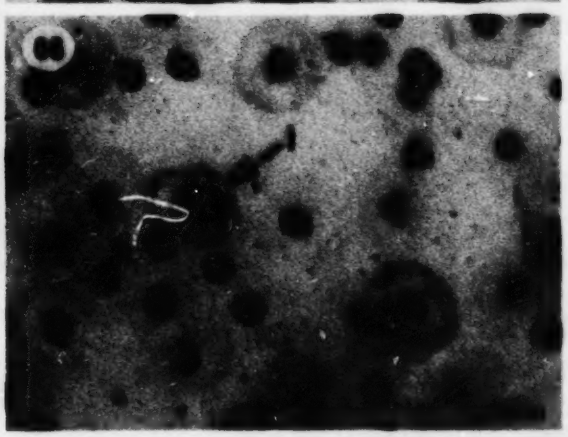

Table 1. Histopathology - 1980 Survey - Scotian Banks.

Fish species and tissues	No. checked	Abnormalities noted
Cod		
Gills	9	4 - no abnormalities 4 - nodule of unknown etiology 1 - hyperplasia and clubbing 1 - small multicellular organisms between lamellae 2 - microsporidia, presumably Loma morhua 6 - aneurysms in lamellae
Liver	10	No abnormalities. Fat content of cells varied in different animals. 6 - cells very vacuolated Scattered macrophages. 1 - small melano-macrophage centres.
Pyloric caeca	10	8 - no abnormalities. 2 - many larval helminths including plerocercoids.
Intestine	10	No abnormalities.
Spleen	10	No abnormalities. Many small melano-macrophage centres with yellow and some dark pigment.
Swimbladder	1	Contained white material Goussia gadi present.
Haddock		
Gills	10	2 - no abnormalities. 3 - nodule of unknown etiology 3 - hyperplasia and clubbing 1 - copepod attached 1 - metacercarian cyst. 8 - aneurysms in lamellae
Liver	10	No abnormalities. 4 - cells vacuolated.
Pyloric caeca	10	8 - no abnormalities 1 - nematode 1 - granuloma
Intestine	10	No abnormalities.
Spleen	10	No abnormalities. Many small melano-macrophage centres with yellow and some dark pigment.

Table 1. cont'd.

Fish species and tissues	No. checked	Abnormalities noted
Haddock (not belonging to above group)		
Swimbladder	2	Contained white material Goussia gadi present.
Silver hake		
Gills	10	5 - no abnormalities 4 - nodule of unknown etiology 1 - hyperplasia 2 - aneurysms in lamellae
Liver	10	5 - no abnormalities 5 - some cells fairly vacuolated 3 - cells vacuolated 5 - coccidians (probably Goussia sp.) Scattered macrophages, 3 - some small melano-macrophage centres
Pyloric caeca	6	No abnormalities.
Intestine	10	6 - no abnormalities 4 - many rodlet cells 1 - coccidian sporocysts
Spleen	3	1 - no abnormalities 1 - nematode 1 - coccidan (probably Goussia sp.) Many melano-macrophage centres with black and yellow pigment.
Pollock		
Gills	7	5 - no abnormalities 2 - hyperplasia 4 - aneurysms in lamellae
Liver	8	1 - helminth 7 - no abnormalities. Cells vacuolated.
Pyloric caeca	7	3 - no abnormalities 1 - nematode outside caeca, in pancreas 2 - many larval helminths 2 - many rodlet cells
Intestine	8	6 - no abnormalities 2 - many rodlet cells 1 - granuloma at base of mucosa.
Spleen	8	No abnormalities. Many yellow melano-macrophage centres with some dark pigment.

Table 1. cont'd.

Fish species and tissues	No. checked	Abnormalities noted
Mackerel		
Gills	5	2 - no abnormalities 2 - trichodinids 1 - nodules of unknown etiology - metacercarian cysts at bases of some filaments
Liver	5	1 - no abnormalities 4 - coccidians 1 - cells vacuolated
Pyloric caeca	5	2 - no abnormalities 3 - contain helminths, some recognizable as plerocercoids
Intestine	5	4 - no abnormalities 1 - plerocercoids and many rodlet cells
Spleen	3	No abnormalities. Melano-macrophage centres, mainly with dark pigment
Redfish		
Gills	10	6 - no abnormalities 3 - procaryote inclusions 1 - organisms (small fish ?) between gill filaments 3 - aneurysms in lamellae
Liver	10	No abnormalities. 5 - cells vacuolated. 5 - many melano-macrophage centres
Pyloric caeca	9	No abnormalities.
Intestine	10	8 - no abnormalities 1 - granuloma between muscle layers 1 - many rodlet cells
Spleen	8	No abnormalities. Many melano-macrophage centres, with mainly yellow, some dark pigment.
Witch flounder, (Grey sole)		
Gills	5	No abnormalities.
Liver	4	No abnormalities.
Pyloric caeca	5	No abnormalities.
Intestine	5	No abnormalities.
Spleen	1	No abnormalities. Many melano-macrophage centres, with mainly yellow pigment.
American plaice		
Gills	10	1 - no abnormalities 2 - epitheliocystis 9 - *Aporocotyle simplex* eggs and metacercariae present. 1 - aneurysms in lamellae
Liver	10	No abnormalities. 1- cells vacuolated 2 - melano-macrophage centres
Pyloric caeca	10	9 - no abnormalities 1 - nematodes between caeca
Intestine	10	No abnormalities.
Spleen	8	No abnormalities. Melano-macrophage centres with mainly yellow, some dark pigment
Halibut		
Gills	6	1 - prokaryote inclusions and developing stages of blood flukes. 5 - hyperplasia and clubbing
Liver	6	No abnormalities. 2 - cells vacuolated.
Pyloric caeca	6	No abnormalities.
Intestine	6	No abnormalities.
Spleen	5	No abnormalities. Melano-macrophage centres small, with mainly dark pigment.
Yellowtail flounder		
Gills	4	No abnormalities.
Liver	2	No abnormalities.
Pyloric caeca	3	No abnormalities.
Intestine	3	No abnormalities.
Spleen	1	No abnormalities. Melano-macrophage centres have mainly yellow pigment.
Winter flounder		
Gills	1	No abnormalities.
Liver	1	No abnormalities.
Pyloric caeca	1	No abnormalities.
Spleen	1	No abnormalities. Few melano-macrophage centres

Table 2. Histopathology - 1981 Survey - Approaches to Halifax Harbour, off Chebucto Head.

Fish species and tissues	No. checked	Abnormalities noted
Alewife (Gaspereau)		
Gills	1	No abnormalities.
Liver	1	No abnormalities.
Pyloric caeca	1	No abnormalities.
Intestine	1	No abnormalities.
Spleen	1	No abnormalities.
Kidney	1	Organism (?) in large collecting ducts. No spores seen.
Head kidney	1	Eosinophilic inclusions in base of cells in some tubules.
Gonad	1 ♀ - mature	
Heart	1	No abnormalities.
Herring		
Gills	6	3 - no abnormalities 2 - hyperplasia and fusion 2 - prokaryote inclusions 1 - aneurysms in lamellae
Liver	6	3 - no abnormalities 2 - Goussia clupearum present 1 - granuloma 2 - cells vacuolated
Pyloric caeca	6	4 - no abnormalities 2 - larval helminths in lumen, some identifiable as plerocercoids
Intestine	6	1 - no abnormalities 5 - many eosinophilic granular cells
Spleen	4	No abnormalities.
Kidney	5	No abnormalities.
Head kidney	5	No abnormalities.
Gonad	2 ♀ - immature 1 ♀ - maturing 1 ♂ - maturing 1 ♂ - immature (?)	
Heart	5	No abnormalities.
Cod		
Gills	10	10 - areas of hyperplasia and fusion of lamellae 4 - nodule of unknown etiology 1 - 2 metacercarian cysts in filament
Liver	10	9 - no abnormalities 1 - nematode 2 - cells very vacuolated
Intestine	8	5 - no abnormalities 1 - nematode in lumen 1 - plerocercoid attached to gut epithelium 1 - many rodlet cells
Spleen	10	No abnormalities Many small melano-macrophage centres.
Pyloric caeca	10	3 - no abnormalities 5 - larval helminths, some identifiable as plerocercoids 2 - many rodlet cells
Kidney	10	2 - no change. Little melanin 5 - myxosporidian in tubules 2 - granulomas. Some contain protozoan - probably coccidian 9 - rodlet cells in large ducts
Head Kidney	10	3 - no abnormalities 6 - myxosporidian in tubules 1 - granulomas
Gonad	3 ♂ - immature 5 ♀ - maturing 1 ♂ - maturing 1 ♂ - mature	
Heart	10	7 - no abnormalities 2 - metacercarian cysts in wall 1 - large granuloma
Haddock		
Gills	10	7 - no abnormalities 3 - small regions of fusion of lamellae
Liver	10	No abnormalities. 2 - cells very vacuolated
Pyloric caeca	10	3 - no abnormalities 5 - larval helminths, some identifiable as plerocercoids 1 - nematode 1 - granulomas
Intestine	10	5 - no abnormalities 3 - nematode outside intestine 1 - nematode in lumen of intestine 1 - metacercarian cyst in submucosa

Table 2. Cont'd

Fish species and tissues	No. checked	Abnormalities noted
Spleen	9	No abnormalities. Many small melano-macrophage centres.
Kidney	10	2 - no abnormalities 5 - myxosporidian in tubules 3 - granulomas. Some contain protozoan - probably coccidian zygotes
Head kidney	10	5 - no abnormalities 4 - myxosporidian in tubules 2 - granulomas containing coccidia. In 1 case zygotes free in tubules.
Gonad	2 ♀ - immature 1 - v. immature 1 ♀ - mature 2 ♂ - mature	thin thread with myxosporidia attached.
Heart	6	No abnormalities.
Silver hake		
Gills	2	Hyperplasia. Some rodlet cells in epithelium.
Liver	2	No abnormalities. Cells vacuolated.
Pyloric caeca	2	1 - larval helminths 2 - many rodlet cells 1 - coccidia in epithelial cells
Intestine	2	Some rodlet cells.
Spleen	2	Many melano-macrophage centres with much melanin.
Kidney	2	Many melano-macrophage centres.
Head Kidney	2	Many melano-macrophage centres with much melanin. Eosinophilic granules in epithelial cells of some tubules.
Gonad	2 ♀ - maturing	
Atlantic wolffish		
Gills	1	No abnormalities.
Liver	1	Eosinophils around blood vessels. Yellow melano-macrophage centres.
Intestine	1	No abnormalities.
Spleen	1	Melano-macrophage centres mainly yellow.
Kidney	1	Many rodlet cells in larger ducts.
Head kidney	1	Several round reddish melano-macrophage centres with little melanin.
Gonad	1 ♂ -	Spent, with immature germ cells developing.
Heart	1	Some granulomas.
Snake blenny		
Gills	1	Trichodinids Prokaryote inclusions
Liver	1	No abnormalities.
Pyloric caeca	1	No abnormalities.
Intestine	1	Many rodlet cells.
Spleen	1	Small melano-macrophage centres.
Kidney	1	Many rodlet cells in large ducts.
Gonad	1 ♂ - immature	
Heart	1	No abnormalities
Sea raven		
Gills	1	Procaryote inclusion.
Liver	1	No abnormalities. Cells vacuolated.
Pyloric caeca	1	Plerocercoids attached to mucosa.
Intestine	1	Plerocercoids between folds of mucosa.
Spleen	1	No abnormalities.
Kidney	1	Many rodlet cells in large ducts.
Head kidney	1	Rodlet cells in epithelium of tubule.
Gonad	1 ♀ - maturing	
Heart	1	No abnormalities.
Witch flounder		
Gills	2	1 - no abnormalities 1 - some hyperplasia
Liver	2	No abnormalities. Yellow melano-macrophage centres. 1 - cells vacuolated

Table 2. Cont'd

Fish species and tissues	No. checked	Abnormalities noted
Pyloric caeca	2	Some rodlet cells
Intestine	2	1 - no abnormalities 1 - rodlet cells
Spleen	1	Large, yellow melano-macrophage centres
Kidney	2	1 - Many rodlet cells in larger ducts. Many yellow melano-macrophage centres with little melanin.
Head kidney	2	Many yellow melano-macrophage centres with little melanin. Large well-defined glandular area.
Gonad	2 ♀ - mature	
American plaice		
Gills	7	4 - Epitheliocystis 6 - Aporocotyle simplex in filament
Liver	7	5 - no abnormalities 1 - yellow melano-macrophage centres 1 - cells vacuolated 1 - group of eosinophils 1 - organisms, probably myxosporidian, in bile ducts (no spores seen).
Pyloric caeca	7	1 - no abnormalities 5 - many rodlet cells 1 - inclusions in epithelial cells
Intestine	7	All - many rodlet cells. 1 - groups of small coccidia. 6 - granular inclusions in cells.
Spleen	7	5 - many melano-macrophage centers 2 - fewer Reddish-brown color
Kidney	7	Many melano-macrophage centres, with little melanin.
Head kidney	7	Reddish melano-macrophage centres. Large well-defined glandular area.
Gonad	5 ♀ - immature. 1 ♀ - mature. 1 ♂ - mature.	
Heart	7	1 - no abnormalities. 6 - Aporoctyle simplex
Yellowtail flounder		
Gills	1	No abnormalities.
Liver	1	No abnormalities. Cells vacuolated
Pyloric caeca	1	No abnormalities.
Intestine	1	large worm, possibly trematode
Spleen	1	Few, small light-brown melano-macrophage centres.
Kidney	1	Organisms, probably myxosporidia, in larger ducts. (No spores seen).
Gonad	1 ♀ - mature	
Heart	1	No abnormalities.

Table 3. Histopathology - 1981 Survey - Emerald Bank.

Fish species and tissues	No. checked	Abnormalities noted
Herring		
Gills	5	3 - no abnormalities 1 - procaryote inclusion 2 - aneurisms in lamellae
Liver	5	4 - no abnormalities 1 - spores of Goussia clupearum
Pyloric caeca	5	2 - no abnormalities 2 - larval cestodes 1 - granuloma and trematodes
Intestine	5	4 - no abnormalities 1 - many rodlet cells
Spleen	5	Few, scattered melano-macrophages.
Kidney	5	Several melano-macrophages.
Head kidney	4	No abnormalities. A few yellowish melano-macrophage centres.
Heart	5	No abnormalities.
Gonad	1 ♂	- immature -Light E. sardinae infection
	1 ♂	- maturing -Heavy E. sardinae infection
	1 ♀	- immature
	2 ♀	- maturing
Cod		
Gills	6	2 - no abnormalities 4 - hyperplasia and fusion 1 - nodule of unknown etiology
Liver	6	Vary in density of cell contents. 1 - cells vacuolated 1 - granuloma
Pyloric caeca	6	1 - no abnormalities 5 - larval helminths including plerocercoids
Intestine	6	4 - no abnormalities 2 - many rodlet cells
Spleen	6	Very small melano-macrophage centres with little melanin. 1 - granulomas, 1 probably containing microsporidian Loma morhua
Kidney	6	Several small melano-macrophage centres.
Head kidney	6	5 - myxosporidian in tubules. 1 - coccidians 4 - many rodlet cells in large tubules 1 - trematode
		1 - no abnormalities 4 - myxosporidian in tubules. 1 - granulomas containing coccidia (zygotes and spores). 3 - many rodlet cells.
Gonad	3 ♀	- immature -myxosporidian (?)
	2 ♀	- maturing on outside edge.
	1 ♂	- immature
Heart	6	5 - no abnormalities 1 - granuloma on outside of ventricle
Haddock		
Gills	10	1 - no abnormalities 7 - hyperplasia and fusion 6 - nodule of unknown etiology 3 - microsporidia 1 - Ichthyobodo sp.
Liver	10	8 - no abnormalities 1 - cells vacuolated 1 - small groups of eosinophils
Pyloric caeca	10	6 - no abnormalities 1 - granulomas 2 - larval cestodes and trematodes. 1 - many rodlet cells
Intestine	10	8 - no abnormalities 1 - plerocercoids 1 - nematode in lumen
Spleen	10	Many small melano-macrophage centres.
Kidney	10	Many small melano-macrophage centres. 4 - myxosporidian in tubules 7 - granulomas containing coccidians.
Head kidney	10	2 - no abnormalities 4 - myxosporidians in tubules 4 - granulomas containing coccidia. Free zygotes and oocysts containing sporoblasts in collecting duct in 1 case

Table 3. Cont'd

Fish species and tissues	No. checked	Abnormalities noted
Gonad	3	- immature (2-♂?)
	2 ♂	- mature
	1 ♂	- almost spent
	3 ♀	- immature
	1 ♀	- spent
Heart	10	9 - no abnormalities
		1 - metacercarian cyst
Silver hake		
Gills	2	1 - no abnormalities
		1 - nodule of unknown etiology
Liver	2	1 - cells vacuolated
Pyloric caeca	1	Many rodlet cells.
Intestine	2	No abnormalities.
Spleen	2	Small groups of very black melanocytes.
Kidney	2	Many melano-macrophage centres with much melanin.
Gonad	1 ♂	- almost spent
	1 ♀	- immature
Heart	2	No abnormalities.
American plaice		
Gills	5	1 - no abnormalities
		1 - small trematode attached to gills in filament
		4 - Aporocotyle simplex
Liver	5	4 - no abnormalities
		1 - granulomas
Pyloric caeca	5	No abnormalities.
Intestine	5	4 - no changes
		1 - rodlet cells
Spleen	5	4 - many fairly large reddish-brown melano-macrophage centres
		1 - very few, pale centers
Kidney	5	Many small melano-macrophage centres with reddish-brown coloring.
		2 - small organisms in tubules
		1 - rodlet cells
		1 - nematode
Head kidney	2	No abnormalities.
Gonad	1 ♂	- immature
	1 ♂	- mature
	1 ♀	- spent
	1	- immature
Heart	5	1 - no abnormalities
		2 - encysted Aporocotyle simplex
		1 - large nematode in ventricle
		1 - granulomas
Halibut		
Gills	1	Some hyperplasia and clubbing.
Liver	1	No changes. Some cells vacuolated.
Pyloric caeca	1	Plerocercoids
Intestine	1	Some rodlet cells.
Spleen	1	Melano-macrophage centres, small, dark.
Kidney	1	Many small melano-macrophage centres.
Head kidney	1	Many small, very dark melano-macrophage centres.
Gonad	1 ♂	- immature - Worms (?) and myxosporidia (?) on outside of gonad.
Heart	1	No abnormalities.
Yellowtail flounder		
Gills	2	1 - no abnormalities
		1 - trichodinids. Some hyperplasia
Liver	4	2 - no abnormalities
		2 - many melano-macrophage centres
Pyloric caeca	4	3 - no abnormalities
		1 - small helminths in epithelium
Intestine	4	1 - no abnormalities
		3 - small helminths (?) in epithelium
		2 - acanthocephala
Spleen	4	Melano-macrophage centres few, small, pale. Few melanocytes.
Kidney	4	Many small melano-macrophage centres.
Head kidney	4	No abnormalities. All hemopoetic and glandular tissue - no tubules.
Gonad	2 ♂	- mature
	2 ♀	- mature
Heart	4	No abnormalities.

Table 4. Histopathology - 1979 Herring Survey - Grand Manan, Bay of Fundy. 20 fish sampled.

Tissues	Abnormalities noted
Gills	18 - no abnormalities. 2 - procaryote inclusions.
Liver	13 - no abnormalities. 7 - Goussia clupearum.
Gall bladder	No abnormalities.
Oesophagus	Rodlet cells sometimes seen, cells with eosinophilic granules in dermis.
Pyloric caeca	11 - no abnormalities, except some rodlet cells. 1 - nematodes in lumen. 4 - plerocercoids in lumen. 4 - nematode in pancreas between caeca.
Intestine	19 - no abnormalities. 1 - nematode in adipose tissue outside pancreas. Rodlet cells often seen.
Kidney	No abnormalities. Rodlet cells seen in some.
Head kidney	Melano-macrophage centres few and small, with few melanocytes
Gonad	All immature - 11 ♀, 9 ♂. No abnormalities.
Heart	No abnormalities.
Thyroid	No abnormalities.
Muscle	No abnormalities.
Swimbladder	2 checked - no abnormalities.
Brain	No abnormalities

Table 5. Histopathology - 1981 Herring Survey - Gulf of St. Lawrence. 20 fish sampled (10 from Escuminac, 10 from Shediac).

Tissues	Abnormalities noted
Gills	17 - no abnormalities noted. 1 - 2 cysts on lamellae, probably prokaryote inclusions. 2 - aneurisms in lamellae. 2 - some hyperplasia
Liver	3 - no abnormalities. 17 - Goussia clupearum.
Gallbladder	No abnormalities noted. Many cells with eosinophilic granules in dermis.
Oesophagus, pyloric caeca and intestine	No abnormalities. Rodlet cells often noted in epithelium. Many cells with eosinophilic granules in dermis. 2 - helminths in lumen of oesophagus

Table 5 - Cont'd

Tissues	Abnormalities noted
Spleen	No abnormalities.
Kidney and head kidney	Small melano-macrophage centres. No abnormalities noted.
Gonad	11 ♀ . 9 ♂ . 8 - Eimeria sardinae.
Heart	19 - no abnormalities. 1 - coccidia in heart muscle.
Thyroid	No abnormalities.

Table 6. Histopathology - 1982 Herring Survey, from Chebucto Head area in approaches to Halifax Harbour. 28 fish sampled

Tissues	Abnormalities noted
Liver	8 - no abnormalities. 20 - Goussia clupearum.
Gonad	3 - immature. 13 ♀ . 12 ♂ . 9-Eimeria sardinae.

Table 7. Histopathology - 1984 Pollock Survey, Dark Harbour, Grand Manan, near cages containing salmon (10 juveniles 28-32 cm long).

Tissues	Abnormalities noted
Gills	7 - no abnormalities. 2 - hyperplasia and fusion. 1 - granulomatous cysts. 2 - metacercarian cysts.
Liver	All very vacuolated.
Gallbladder	3 - no abnormalities. 7 - Myxidium gadi in lumen.
Stomach	8 - no abnormalities. 2 - nematode in lumen.
Pyloric caeca	7 - no abnormalities. 3 - plerocercoids. Some in tissues, others in lumen. Many rodlet cells seen in some.
Intestine	No abnormalities.
Spleen	Melano-macrophage centres small with little melanin. Number differed in different samples.
Kidney	Small melano-macrophage centres. 7 - no abnormalities. 3 - granulomas.
Gonad	All immature. 3 ♀. 7 ♂.
Heart	No abnormalities.

Table 8. Prevalence of some parasite species found during 1980 Marine fish survey of Scotian Bank.

PARASITE		PREVALENCE OF PARASITE							
Phylum	Species	Cod*	Haddock	Silver hake	Pollock	Herring	Mackerel	Flatfish	Redfish
Nematoda	A. simplex	52%	28%	41%	94%		47%	24%	47%
	P. decipiens	59%						33%	
	Enteric nematodes	81%	40%	12%	91%		29%	28%	8%
Cestoda	A. gadi	5%	25%						
	C. crassiceps			14%					
	B. sturionis							1%	
	B. scorpii							2%	
	Eubothrium sp.								6%
	Pleroceroid								3%
Acanthocephala	Echinorhynchus sp.& Corynosoma sp.	52%	40%		15%			7%	
Digenea	S. formosum							1%	
Copepoda	L. branchialis	2%							
	C. adunca	10%	2%		6%				
	H. hippoglossi							8%	
Haemogregarines	H. aeglefini		12%						
	H. sp(p)			12%			6%	1%	10%
Bacteria in blood			2%	6%	3%		6%	3%	13%
Inclusions in erythrocytes			25%	14%	6%	100%	6%	5%	7%
Statistics									
Total no. of fish		58(29)*	83	66	33	1	17	99(48)**	72
Range of lengths(cm)		33-98	20-74	21-56	51-96	29	32-42	22-60	12-53
Male		28	27	16	16		7	31	33
Female		29	46	47	17		10	68	32
Immature		1	10	3		1			7

* only 29 bodies **only 48 bodies saved for identification and counts of parasites in fillets and napes.

Table 9. Parasitology - species of parasites found and sites in samples.

Nematoda:
1) Pseudoterranova (Phocanema) decipiens (larval): fillets and napes.
2) Anisakis simplex (larval): liver, mesenteries, pyloric caeca, coelom.
3) Enteric nematodes: stomach and intestine. (The majority were Hysterothylacium sp(p).).

Cestoda:
1) Cleistobothrium crassiceps: intestine.
2) Abothrium gadi: intestine, often with anterior end in pyloric caeca.
3) Eubothrium sp.: intestine.
4) Bothriocephalus scorpii: intestine.
5) Bothrimonus sturionis: intestine.

Acanthocephala:
1) Echinorynchus sp.:
2) Corynosoma sp:
} intestine. Also in mesenteries.

Digenea:
1) Steganoderma formosum: pyloric caeca.
2) Metacercariae (Crytocotyle lingua; Stephanostomum baccatum) in musculature and dermis.

Copepoda:
1) Clavella adunca: gills.
2) Lernaeocera branchialis: gills.
3) Hatschekia hippoglossi: gills.

All protozoa are found in the blood.

Haemogregarine is probably Haemogregarina aeglefini.

Bacteria in blood may be due to contamination.

Table 10. Microbiological Surveys of Marine Fish Species by Fish Health Service Unit 1980-1982.

Location	Date (D/M/Y)	Species	No. examined	Results
Scotian Shelf (from Halifax harbour south to Bay of Fundy)	7-16.7.80	Haddock	89	No bacterial fish pathogens detected in kidneys or guts of any species. Pseudomonas sp. and Flavobacter isolated from guts of all species except haddock, where Vibrio sp. and marine micrococci predominated. No viral pathogens from all species except cod when Infectious Pancreatic Necrosis virus (IPNV) was detected
		Redfish	72	
		Cod	67	
		Pollock	72	
		Halibut	14	
		Silver hake	49	
		A. plaice	42	
Scotian Shelf (from Halifax harbour north to Cabot Strait)	17-27.7.80	Haddock	57	No bacterial fish pathogen detected in kidneys or guts of any species. Pseudomonas sp., Flavobacter, and micrococci predominated in the guts of most species. No viral pathogen detected.
		Cod	74	
		A. plaice	81	
		Silver hake	47	
		Redfish	60	
		Yellowtail flounder	9	
		Mackerel	9	
		Pollock	3	
		Herring	1	
		Winter flounder	1	
		Witch flounder	5	
		Halibut	1	
Chebucto Head (Approaches to Halifax Hr.)	23.4.81	Cod	60	No abnormalities observed on necropsy in any species. No bacterial pathogens from kidney or guts. Vibrio sp. from guts of all species. No viral fish pathogens from any species.
		A. plaice	60	
		Haddock	23	
		Witch flounder	2	
Emerald Bank	29.4.81	Haddock	60	No abnormalities observed on necropsy in any species. No bacterial or viral fish pathogens isolated from any species.
		A. plaice	60	
		Witch flounder	1	
		Halibut	1	
Escuminac, N.B.	6.5.81	Herring	120	No abnormalities observed on necroposy. No bacteria isolated from any kidneys, Pseudomonas, Vibrio, Flavobacter, Alkaligines, isolated from guts of Escuminac fish. Pseudomonas, motile aeromonads, and Vibrio Isolated from guts of Shediac fish. No viral pathogens isolated from any fish.
Shediac, N.B.	14.5.81	Herring	120	
St. Mary's Bay, N.B.	8.7.81	Herring	60	
Emerald Bank	30.6.81	Haddock	60	No abnormalities observed. No bacteria isolated from kidneys. Common marine species of bacteria only isolated from guts of both species. No viral pathogens isolated.
		Flatfish	60	
Chebucto Head, N.S.	2.7.81	Haddock	9	No abnormalities observed. No bacterial isolates from kidneys. Only common marine bacterial species from guts of all species. No viral pathogens isolated.
		Flatfish	60	
		Cod	31	
		Herring	20	
Chebucto Head, N.S.	3.3.82	Herring	60	No abnormalities observed on necropsy. No bacteria or viral fish pathogens detected at any site.
Bay de Chaleur	30.4.82	Herring	60	
Shediac, N.B.	5.5.82	Herring	60	

Table 11. Diagnoses - Individual marine species cases submitted to the Fish Health Service Unit 1981-1984.

Location	Date (D/M/Y)	Species	No. examined	Results
Halifax Laboratory aquarium	17.08.81	Cod	2	Mortalities caused by Aeromonas salmonicida (see Cornick, Morrison, Zwicker and Shum 1984).
Deer Island	7.10.81	Herring	12	Salt requiring yellow vibrio found in guts.
	25.11.81	Haddock	1	Pink colored yeast Rhodotorula sp. associated with pink color in flesh.
Halifax Laboratory aquarium	19.01.82	Cod	2	Death caused by vibriosis (Vibrio anguillarum) in lesions and guts.
	9.06.82	Cod	1	Mortality. Pseudomonas sp. found.
	15.11.82	Cod	1	Mortalities caused by vibriosis.
	16.11.82	Haddock	1	
Lockeport, N.S.	18.08.83	Haddock	1	Red color. No pink colored yeast. No bacterial or viral pathogens isolated.
		Pollock	1	
	13.07.83	Haddock	1	
	15.07.83	Cod	1	No bacterial pathogens isolated.
	7.10.83	Cusk	1	Growth on skin - no bacterial pathogens isolated.
Halifax Laboratory aquarium	15.11.83	Cod	1	Mortality caused by vibriosis.
		Haddock	1	
Shippigan	25.1.84	Alewife(Gaspereau)	4	Coccidian, probably Goussia sp., in liver.